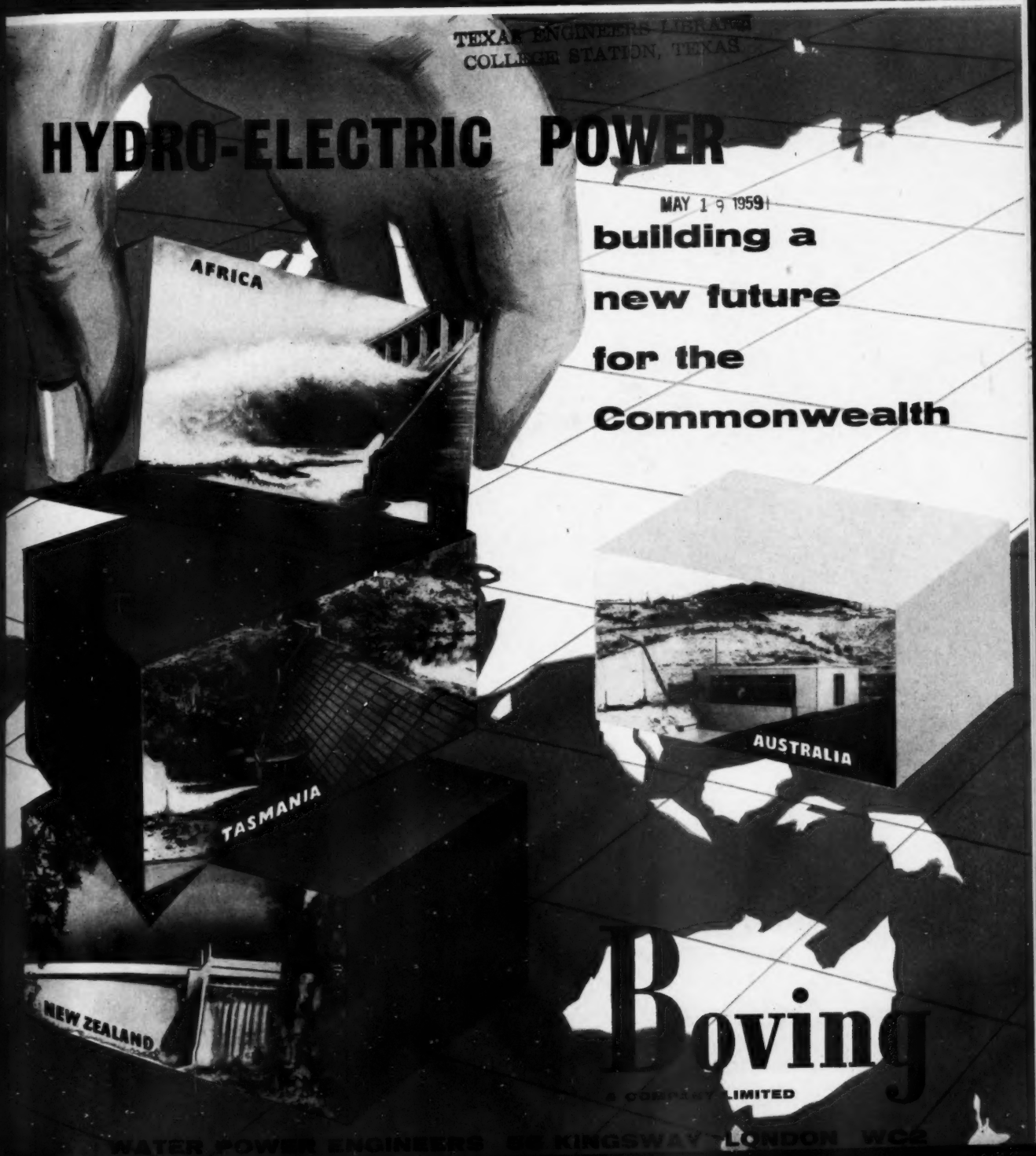
Water Power

AN INTERNATIONAL DEVELOPMENT OF HYDRO-ELECTRIC POWER

MAY 1959

TEXAS ENGINEERS LIBRARY
COLLEGE STATION, TEXAS

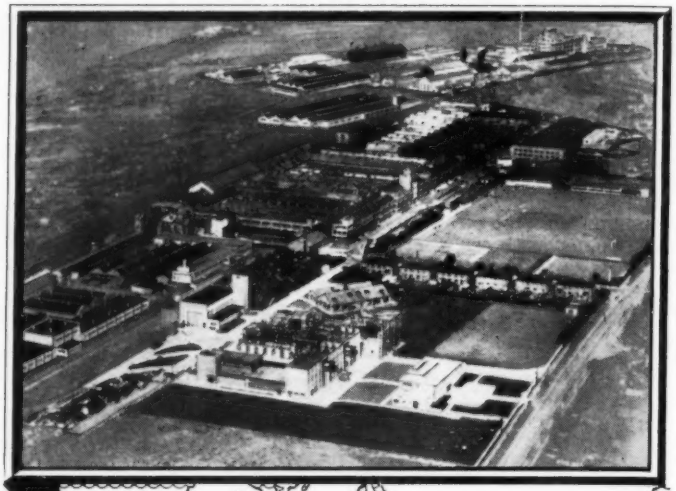


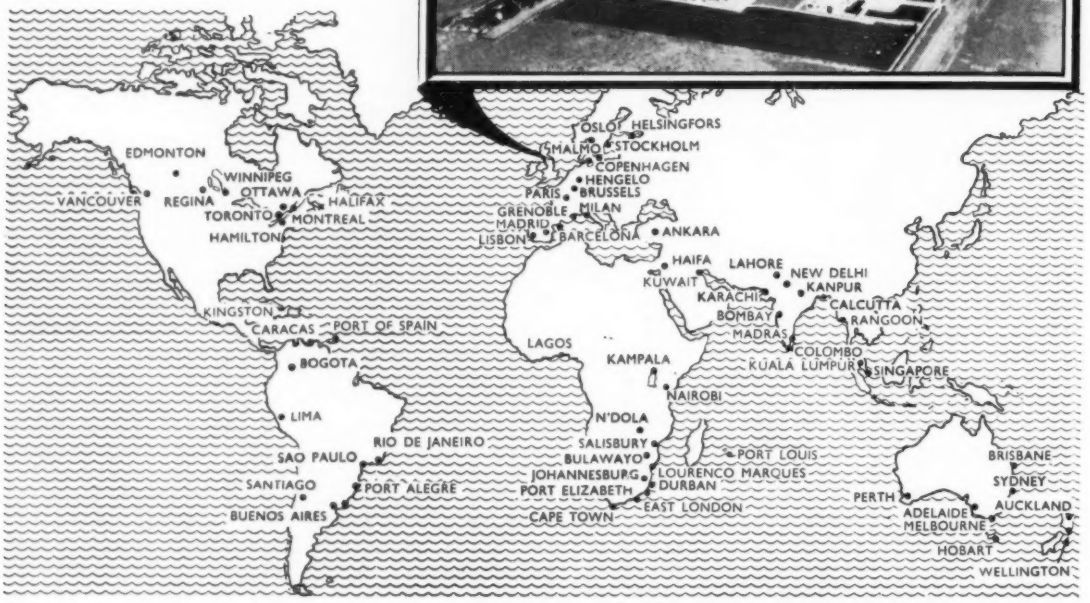
HEBBURN–

THE SOURCE

OF ELECTRICAL

SWITCHGEAR





* ***ENGINEERS AND REPRESENTATIVES AVAILABLE FOR CONSULTATION AND ADVICE***

A WORLD-WIDE ORGANISATION

A WORLD-RENOWNED PRODUCT

REYROLLE

A MEMBER OF THE NUCLEAR POWER PLANT COMPANY LIMITED

A. REYROLLE & CO. LTD. HEBBURN COUNTY DURHAM ENGLAND

still more power for the Highlands

1950 LOCH SLOY
1951 FASNAKYLE
1952 LUSSA
1953 GAUR
1954 LUICHART
1955 CLACHAN
1955 QUOICH
1956 INVERGARRY
1956 CEANNACROC
1957 SRON MOR
1958 LOCHAY
1958 GLENMORISTON

Two 'ENGLISH ELECTRIC' 18,000 kW 375 r.p.m. 285 ft head vertical water turbines and alternators have recently been commissioned in the underground Glenmoriston Power Station of the North of Scotland Hydro-Electric Board. The machines were manufactured at Harland and Wolff's works, Scotstoun.

In nine years, 'ENGLISH ELECTRIC' have installed in Scotland generating equipment with an output of 413,450 kW and water turbines developing 572,960 h.p.

'ENGLISH ELECTRIC'

hydro-electric equipment

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2.

Hydro-electric Department, Netherton, Bootle, 10

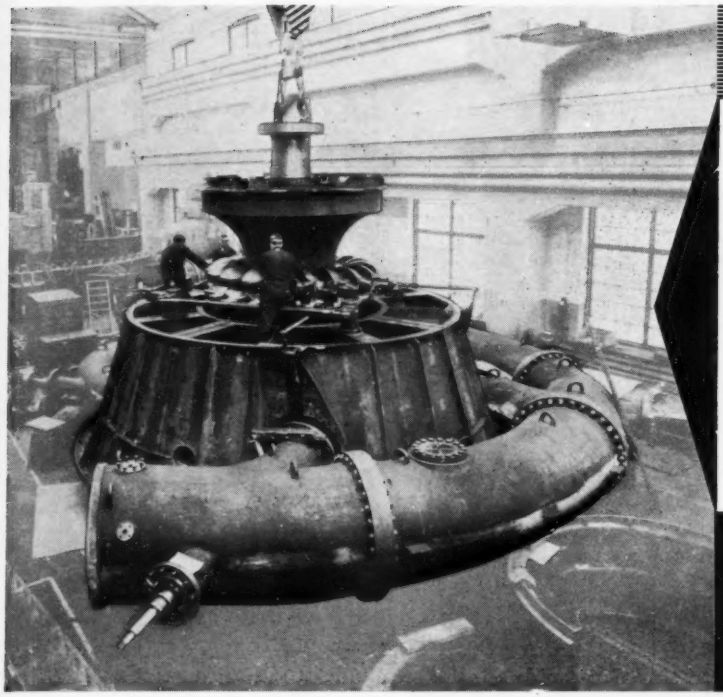
WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

HE.35

power cable
accessories

PG

PIRELLI GENERAL
SOUTHAMPTON



The Largest Vertical

PELTON Turbine

in Norway is a KMW Turbine

In the last half of 1958 the first of the two Pelton Turbines ordered from KMW by the Hjartdöla Power Station in Norway was put into operation; the second unit will be put into service shortly. The turbine has a nominal output of 71,000 H.P. at 555 m (1,820 ft.) net head and 428 r.p.m.

Both the turbines are equipped with the ASEA-KMW system of electro-hydraulic governing. Impulses from the electronic regulator are converted into mechanical motion in the electro-hydraulic actuator. This motion is transmitted via a separate servomotor to the deflectors and the control valves of the needle servomotors, which are linked by a conventional system of cams to provide the correct combination of controls.

This is the first time that an ASEA-KMW electro-hydraulic actuator has been used for a Pelton turbine. When the first unit was started up and put into service, the regulating system operated perfectly without any adjustment. Alterations in speed when throwing-off load were very small and the return to normal revolutions was remarkably quick.

AB KARLSTADS MEKANISKA WERKSTAD

Karlstad - Sweden

Representatives in Canada: A. Johnson & Co. (Canada) Ltd.,
607 Shell Tower Building, Montreal 2.

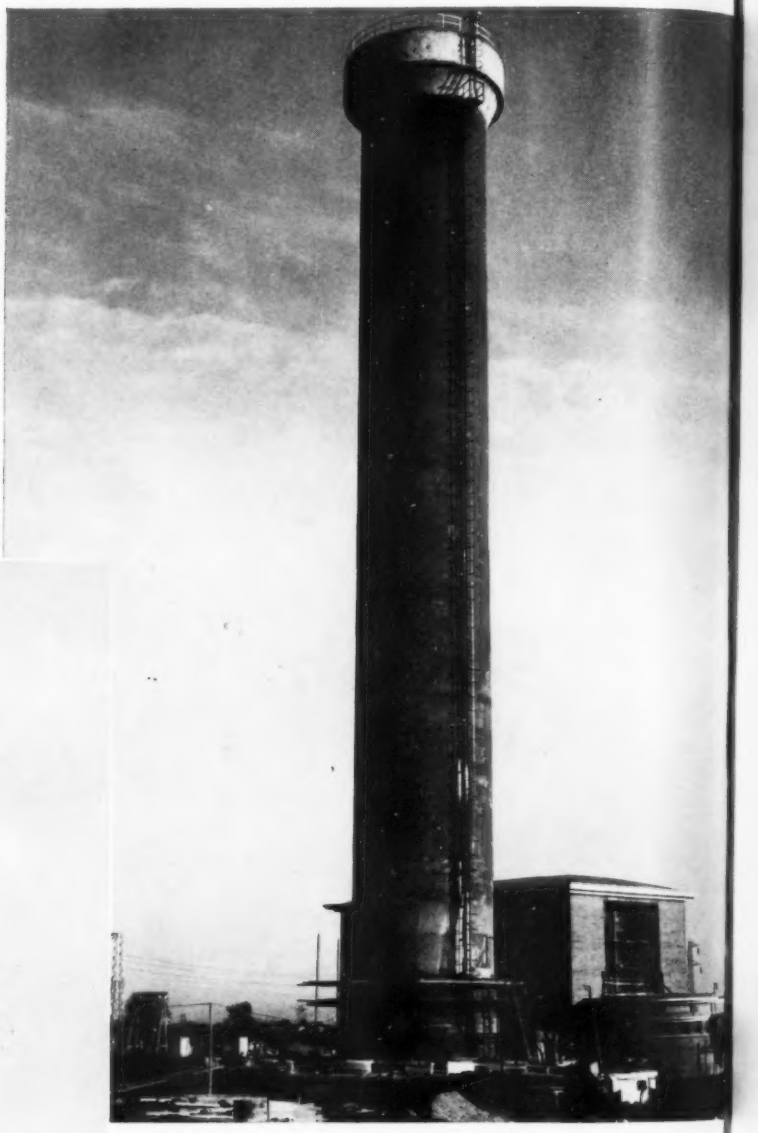
KMW

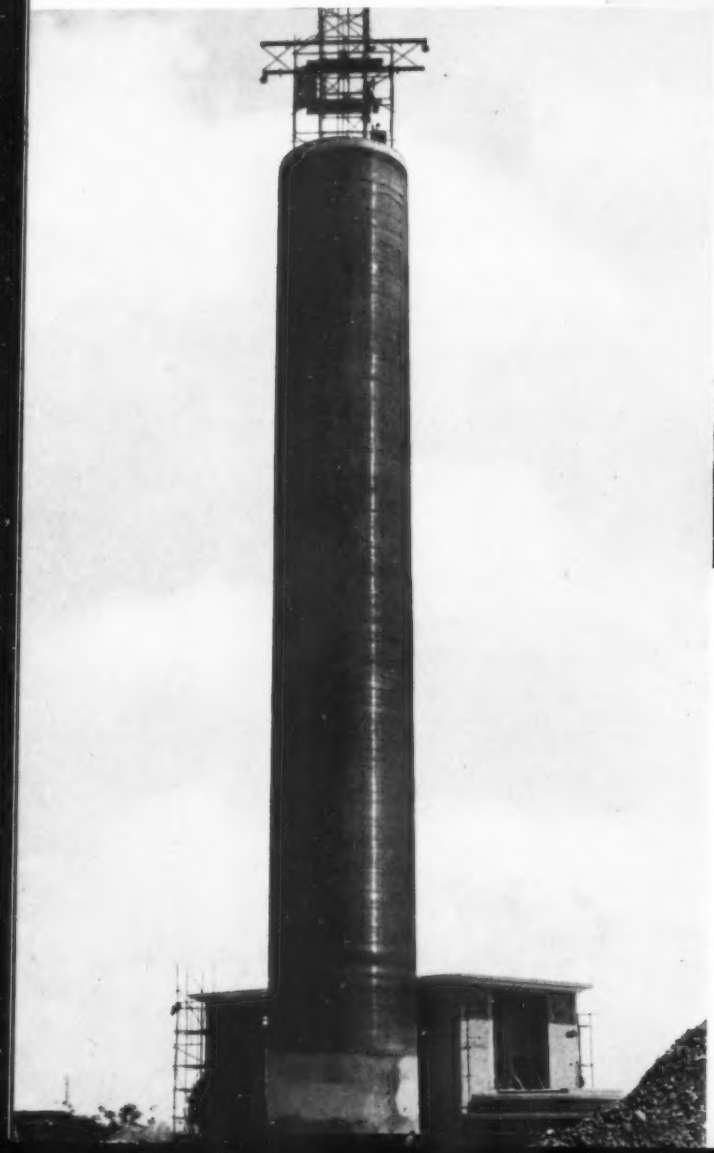
SACAIM

Soc. p. Az. Cementi Armati Ing. Mantelli

VENICE (ITALY) - Accademia 979/A - Telephone 24.072

Normal, special and prestressed reinforced concrete Penstocks of any diameter and pressure.





SURGE TOWER in prestressed reinforced concrete (Diameter 6 metres, Height 60 metres) for the MEDUNA Hydro-electric Station of

S.A.I.C.I.

SOCIETA AGRICOLA INDUSTRIALE PER LA CELLULOSA ITALIANA DI MILANO

Newport News rack rakes . . . minimum-manpower way to keep water intakes free of debris

Newport News mechanical rack rakes are power-operated rakes for cleaning trash racks at water intakes, including those at hydro-electric plants, steam plants, pumping stations, and similar installations throughout this country and abroad. Under ordinary conditions, one man per shift keeps racks clean for a dozen bays.

Operate in channel guides for maximum cleaning action

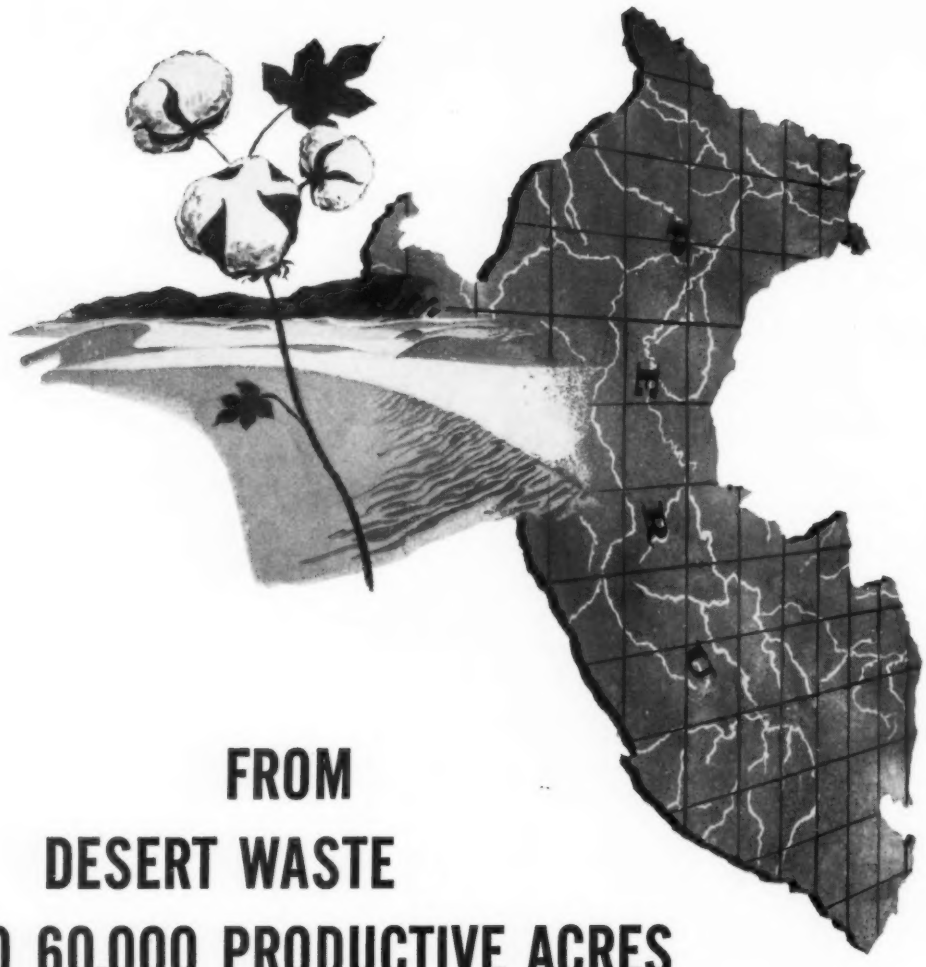
A Newport News rake *won't ride over trash* nor will its teeth drop the debris, because the rake operates in channel guides for positive action. Special teeth are available for cleaning racks of filamentous algae, seaweed, etc.

The Newport News mechanical rack rake has been built to operate in bays from 5 feet 6 inches wide to 28 feet 6 inches in width. Forebay design determines the maximum width for a single rake. In the case of a very wide bay, intermediate guides are sometimes used to reduce the length of the rake. There are many typical installation arrangements to fit your needs. Newport News engineers are prepared to individualize these designs for you.

If you have a debris problem, write for a copy of THE NEWPORT NEWS MECHANICAL RACK RAKE, an illustrated booklet describing the installation, operation, and advantages of a Newport News rake.

Engineers . . . Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

Newport News
Shipbuilding and Dry Dock Company
Newport News, Virginia



FROM DESERT WASTE TO 60,000 PRODUCTIVE ACRES

THROUGH INTERNATIONAL ENGINEERING...

Nearing completion in northern Peru's Rio Quiroz basin is the San Lorenzo Dam, a massive earth-fill structure that will impound a quarter of a billion cubic meters of water behind its quarter-mile span . . . water to irrigate 60,000 acres of new land through a modern system of canals and laterals.

With sufficient water to bring desert soil to life, farmers will grow premium grade long staple cotton for world markets . . . other crops for local consumption. Water from the San Lorenzo reservoir will also stabilize the irrigation needs of an additional 60,000 acres of farm land now subject to severe droughts and consequent crop losses.

Like so many other water and power projects throughout the world, the Rio Quiroz Irrigation Project was designed and engineered by International Engineering.

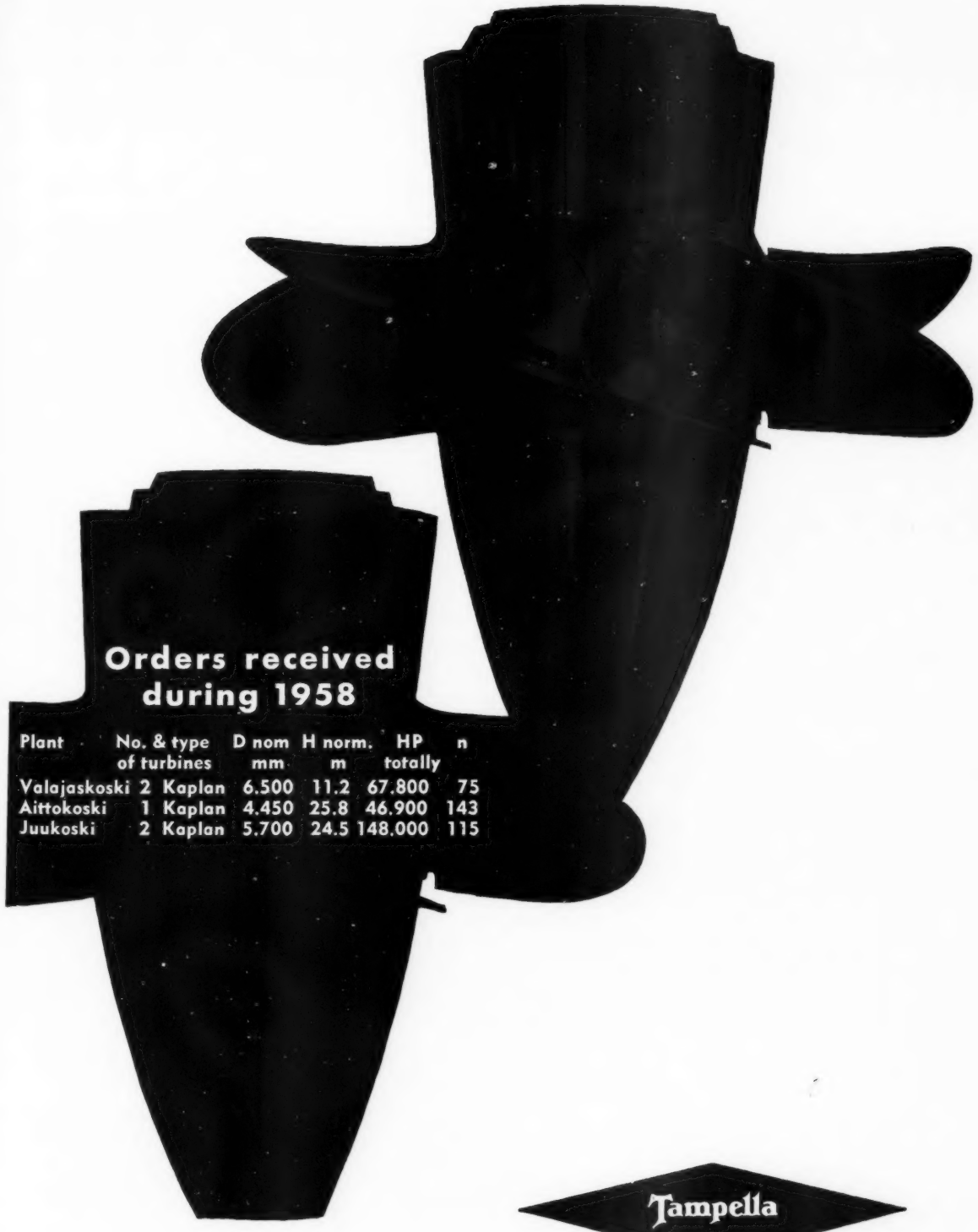
SERVING DESIGN & ENGINEERING NEEDS WORLDWIDE WITH

- Reconnaissance and Surveys
- Preliminary Analyses and Evaluation
- Estimates, Financing Plans and Project Recommendations
- Design Drawings and Construction Specifications
- Analysis of Bids and Bid Recommendations
- Detailed Construction Drawings
- General Engineering Supervision
- Final Reports and Record Drawings

INTERNATIONAL ENGINEERING COMPANY, INC.

74 New Montgomery Street • San Francisco, California, U.S.A.
A subsidiary of Morrison-Knudsen Company, Inc.

For a complimentary copy of our 16-page illustrated brochure, write to Dept 2-E.



Orders received during 1958

Plant	No. & type of turbines	D nom mm	H norm. m	HP totally	n
Valajaskoski	2 Kaplan	6.500	11.2	67.800	75
Aittokoski	1 Kaplan	4.450	25.8	46.900	143
Juukoski	2 Kaplan	5.700	24.5	148.000	115

Tampella

TAMMERFORS LINNE-OCH JERN-MANUFAKTUR
AKTIE-BOLAG ENGINEERING WORKS

ESTABLISHED 1842

TAMMERFORS, FINLAND

BUILDING FOR POWER

Huwood Conveyors are in wide use, not only in Britain but throughout the world—one of their most important applications being in the work of dam building for hydro-electric schemes.

They have been chosen because they offer the highest degree of adaptability to varying sites, the utmost reliability, and the minimum of routine maintenance.

Huwood Conveyors

HUGH WOOD & CO. LTD.

Head Office and Factories
GATESHEAD - ON - TYNE, 11.
Telegrams: Huwood, Gateshead. Telephone: Low Fell 76083 (5 lines).

Industrial and Export Office
ROYAL LONDON HOUSE, FINSBURY SQUARE, LONDON, E.C.2.
Telegrams: Huwood Stock, London. Telephone: Monarch 3273 (4 lines).

Photograph by courtesy of Rhodesian Railways

THE FIRST ONE on the last lap

The first 60,000 kVA 330/33 kV 3-phase double wound transformer en route from Lourenco Marques to Salisbury Sub-Station, for the Kariba Hydro-Electric Scheme.

This forms part of the contract awarded to Ferranti Ltd. by the Federal Power Board, Rhodesia and Nyasaland, comprising two 120,000 kVA 330/234 kV 3-phase auto transformers with series boosters, nine 60,000 kVA, 330/88 kV and two 60,000 kVA, 330/33 kV 3-phase double wound transformers.

The consulting electrical & mechanical engineers are Messrs. Merz & McLellan.

F FERRANTI

Specify* FERRANTI TRANSFORMERS *famous throughout the world

FERRANTI LTD Head Office and Works: HOLLINWOOD · LANCS
Tel: FAllsworth 2000
London Office: Kern House, 36 Kingsway W.C.2. Tel: TEMple Bar 6666

FERRANTI

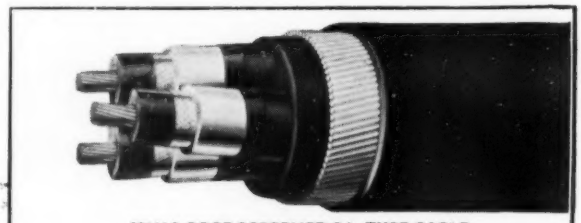
FT 224/2

POWER

Created by Bernini in the 17th century, this lithe sculpture of David stands in the Galleria della Villa Borghese, Rome, a gleaming tribute in bronze to the sculptor's conception of power.

In our modern world, power — electrical power—is the great motivator of our industries, the light and warmth of our homes. And wherever electricity comes from, wherever it goes, Henley cables carry it surely and safely. No manufacturer has more experience in the design and manufacture of supertension cables up to 132 kV.

David, *by Bernini.*
In the Galleria della Villa Borghese, Rome.



33kV 3-CORE SCREENED S.L. TYPE CABLE

POWER CABLES by HENLEY

OT APPOINTMENT TO HIS MAJESTY THE QUEEN ELECTRIC CABLE MANUFACTURERS

W. T. HENLEY'S TELEGRAPH WORKS CO. LTD · 51-53 HATTON GARDEN · LONDON E.C.1 · Tel: CHAncery 6822

M·A·N

HYDRAULIC LABORATORY

In the planning and constructing of hydraulic steel structures it is important to find the most economic and best shaping. For this, model tests are carried out with modern measuring appliances on weirs, locks, deep sluice gates and dry docks. This has enabled the M.A.N. hydraulic laboratory to guarantee the Client reliable advice for the past 50 years.

1356

MASCHINENFABRIK AUGSBURG-NÜRNBERG AG GUSTAVSBURG WORKS
GUSTAVSBURG/HESSEN (GERMANY) REPRESENTATIVES IN ALL COUNTRIES

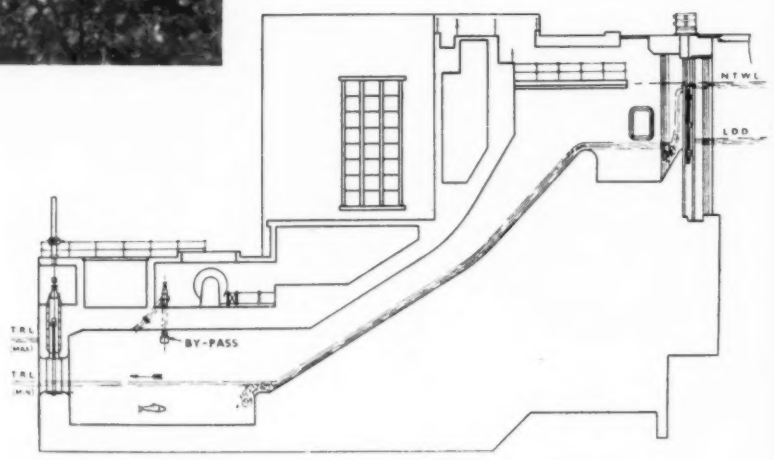
GLENFIELD FISH LIFTS

FOR DAMS AND ELSEWHERE

The Glenfield style of hydraulic fish elevator is now an established part of Hydro-electric practice.

It enables migratory fish to pass upstream or downstream of dams and other obstructions under virtually natural conditions with the minimum of effort, by means that effect considerable savings of funds and improvement of general amenities. In operation it is essentially automatic and can be adjusted to any desired time cycle to suit prevailing conditions.

The illustrations show an installation near a power station in the Scottish Highlands, and the arrangement of one incorporated in the structure of another station in the same area.

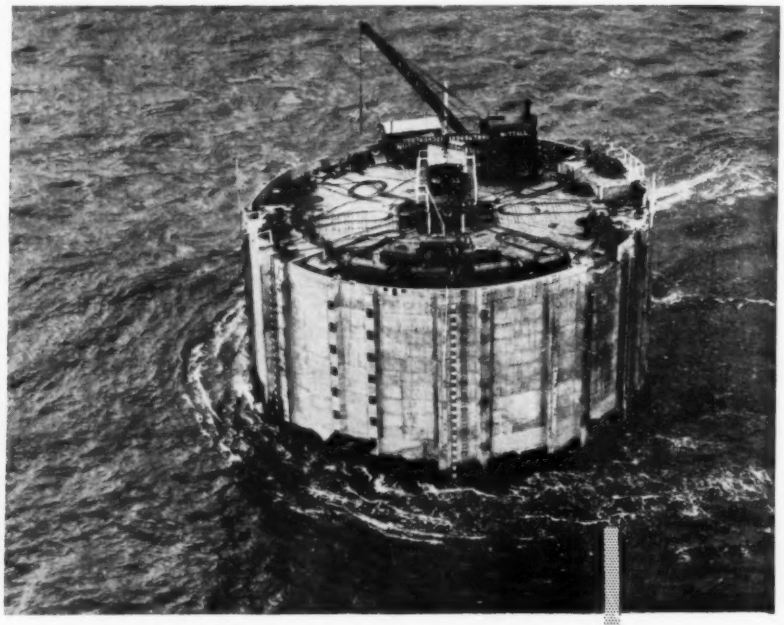


Glenfield

GLENFIELD & KENNEDY, LIMITED, KILMARNOCK

Head Office and Works: Kilmarnock, Scotland

Complete Equipment
for Water Power Plants
Turbines of the Kaplan, Francis and Pelton type for various heads and outputs, transformers, generators, outdoor and indoor switch gear, control-rooms, etc.
The world-known ŠKODA and CKD trade-marks guarantee the first-class technical design and quality of equipment supplied by us. We give integral guarantees for complete deliveries.
TECHNOEXPORT
Foreign Trade Corporation for Export of complete Industrial Plants
56, Václavské náměstí, Praha II,
CZECHOSLOVAKIA



Consulting Engineers: Merz & McLellan and Rendel, Palmer & Tritton
Authority: Central Electricity Generating Board, Midlands Project Group.

ABERTHAW POWER STATION

Our photographs show the various stages in construction of the Intake Caisson which, together with four ten foot diameter tunnels and an 80 ft. deep pumphouse, forms the circulating water system for the Aberthaw Power Station. The Caisson, which is 95 feet in diameter, 65 feet high and weighs 3,500 tons, was constructed on shore and later towed out and sunk onto previously prepared landing pads in the Bristol Channel approximately half a mile off the Welsh coast.

The Spring tides range in the Aberthaw area is 34 feet and the current approximately 4 knots.

The contract for this work was placed on the 2nd September, 1957 and the Caisson was towed out and sunk on the 18th July, 1958.

EDMUND NUTTALL

CIVIL ENGINEERING CONTRACTORS

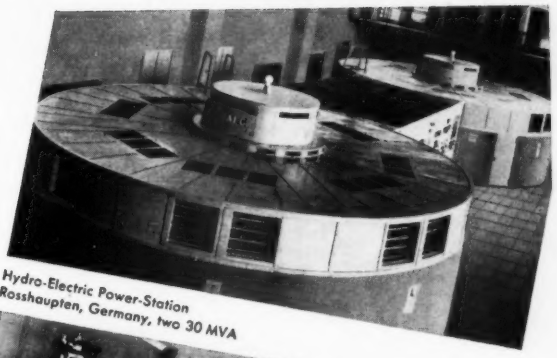
EDMUND NUTTALL, SONS & CO. (LONDON) LTD., 22 GROSVENOR GARDENS, LONDON S.W.1. TELEPHONE: SLOANE 0036

AEG

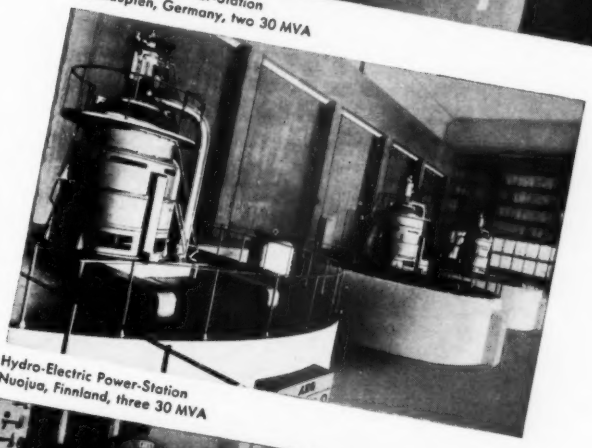
HYDRO-ELECTRIC GENERATORS

For three-quarters of a century we have supplied all types of electrical equipment, especially generators, for hydro-electric plants throughout the world.

A comprehensive reference list will be forwarded upon request.

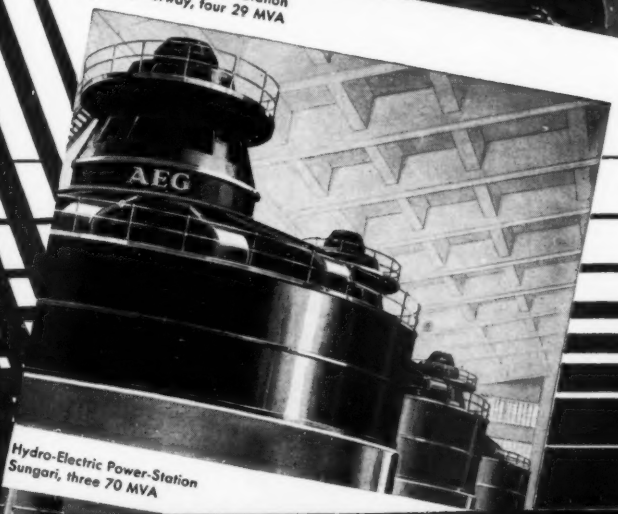


Hydro-Electric Power-Station
Rosshaupten, Germany, two 30 MVA



Hydro-Electric Power-Station
Nuojua, Finnland, three 30 MVA

Hydro-Electric Power-Station
Nore, Norway, four 29 MVA

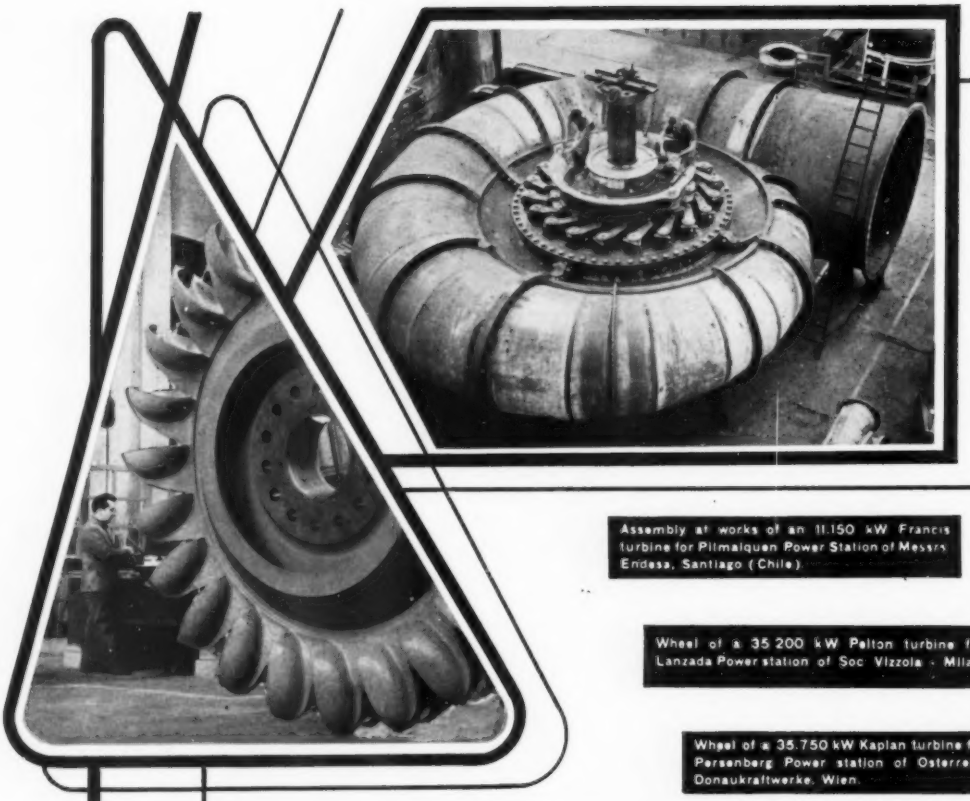


Hydro-Electric Power-Station
Sungari, three 70 MVA

ALLGEMEINE ELEKTRICITÄTS-GESELLSCHAFT

Berlin (West) EXPORT DEPARTMENT Frankfurt (Main)

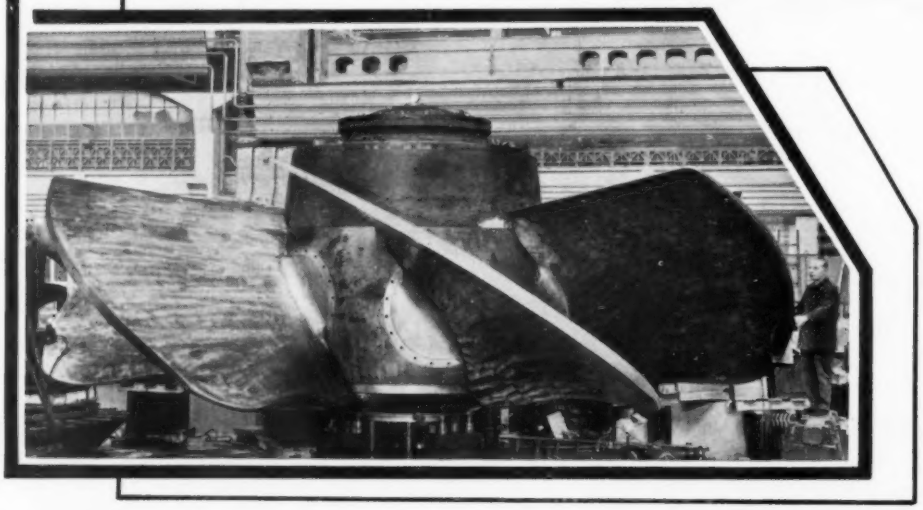
Complete hydro-electric plants



Assembly at works of an 11.150 kW Francis turbine for Pilmaiquen Power Station of Messrs Endesa, Santiago (Chile).

Wheel of a 35.200 kW Pelton turbine for Lanzada Power station of Soc Vizzola - Milan.

Wheel of a 35.750 kW Kaplan turbine for Ybbs Persenberg Power station of Osterreichische Donaukraftwerke, Wien.

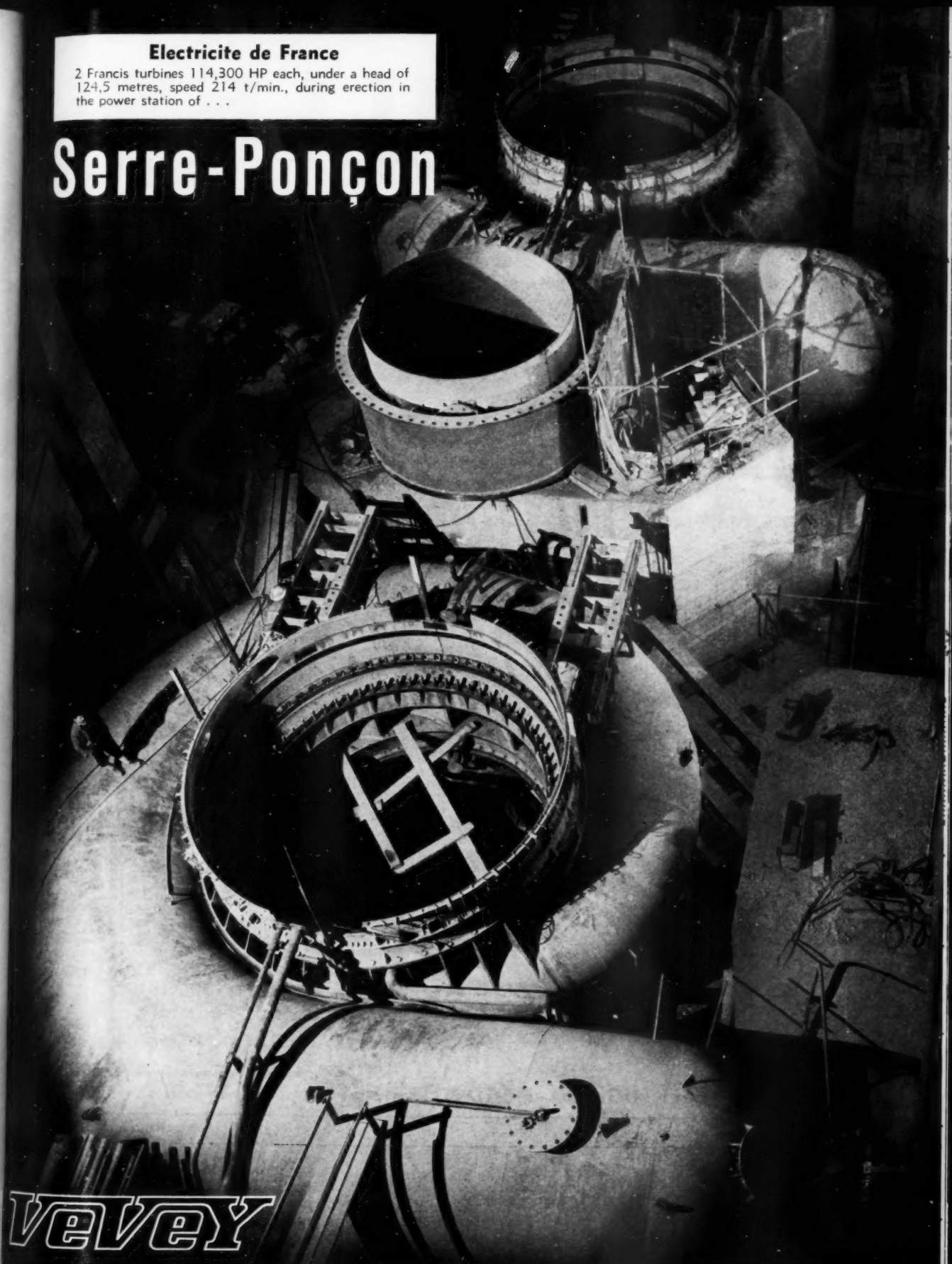


ANSALDO-SAN GIORGIO
GENOVA

Electricite de France

2 Francis turbines 114,300 HP each, under a head of 124,5 metres, speed 214 t/min., during erection in the power station of . . .

Serre-Ponçon



Vevey

Vevey Engineering Works Ltd.

Vevey (Switzerland)

in collaboration with our French licensee:
Cie des Ateliers et Forges de la Loire, St-Chamond (Loire)

CHARMILLES

CHARMILLES ENGINEERING WORKS LTD. - GENEVA

31 000 HP
RUNNER FOR THE HIGHEST HEAD
in the world
5,800 FEET

The highest head
in AMERICA
3,700 FEET
is also equipped with
CHARMILLES TURBINES
LOS MOLLES POWER PLANT
Two 12,650 HP units

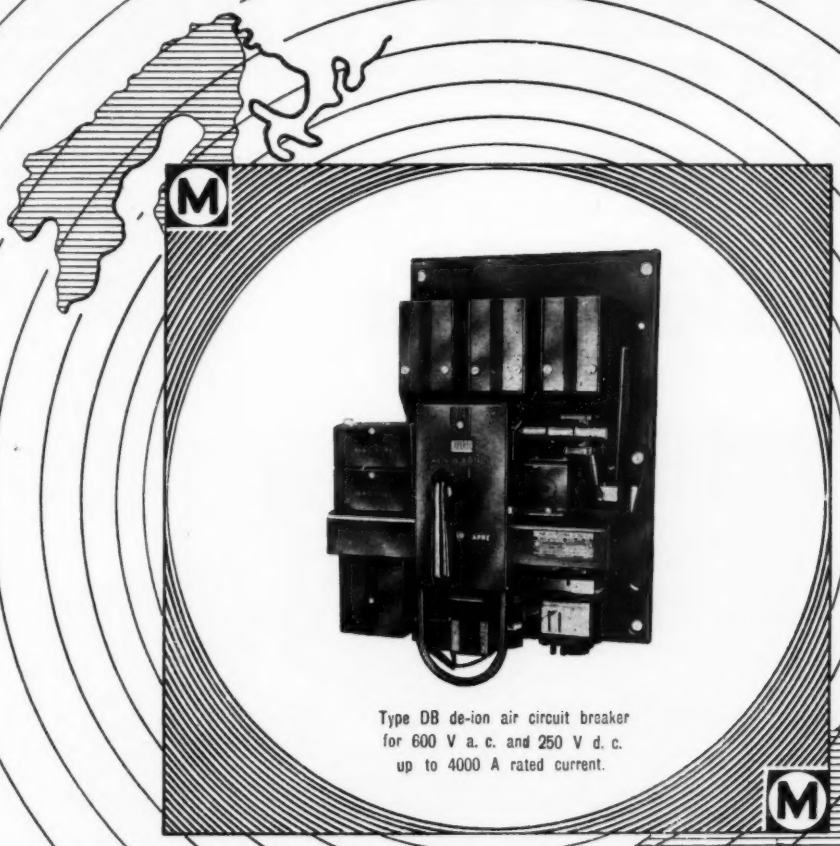
EXCERPT
FROM CHARMILLES
REFERENCE LIST

THE SIXTEEN HIGHEST HEAD TURBINES IN THE WORLD

Installation	Number of units	Net head feet	Unit output HP
Reisseck (Austria)	3	5,800	31,000
Dixence (Switzerland)	5	5,700	50,000
*Fully (Switzerland)	4	5,400	3,000
Miéville (Switzerland)	3	4,730	47,500
Portillon (France)	1	4,280	53,500

*manufactured in the time of Pic-Pic

No other turbine in the world operates with a head equal to or higher than any of the above



Type DB de-ion air circuit breaker
for 600 V a. c. and 250 V d. c.
up to 4000 A rated current.

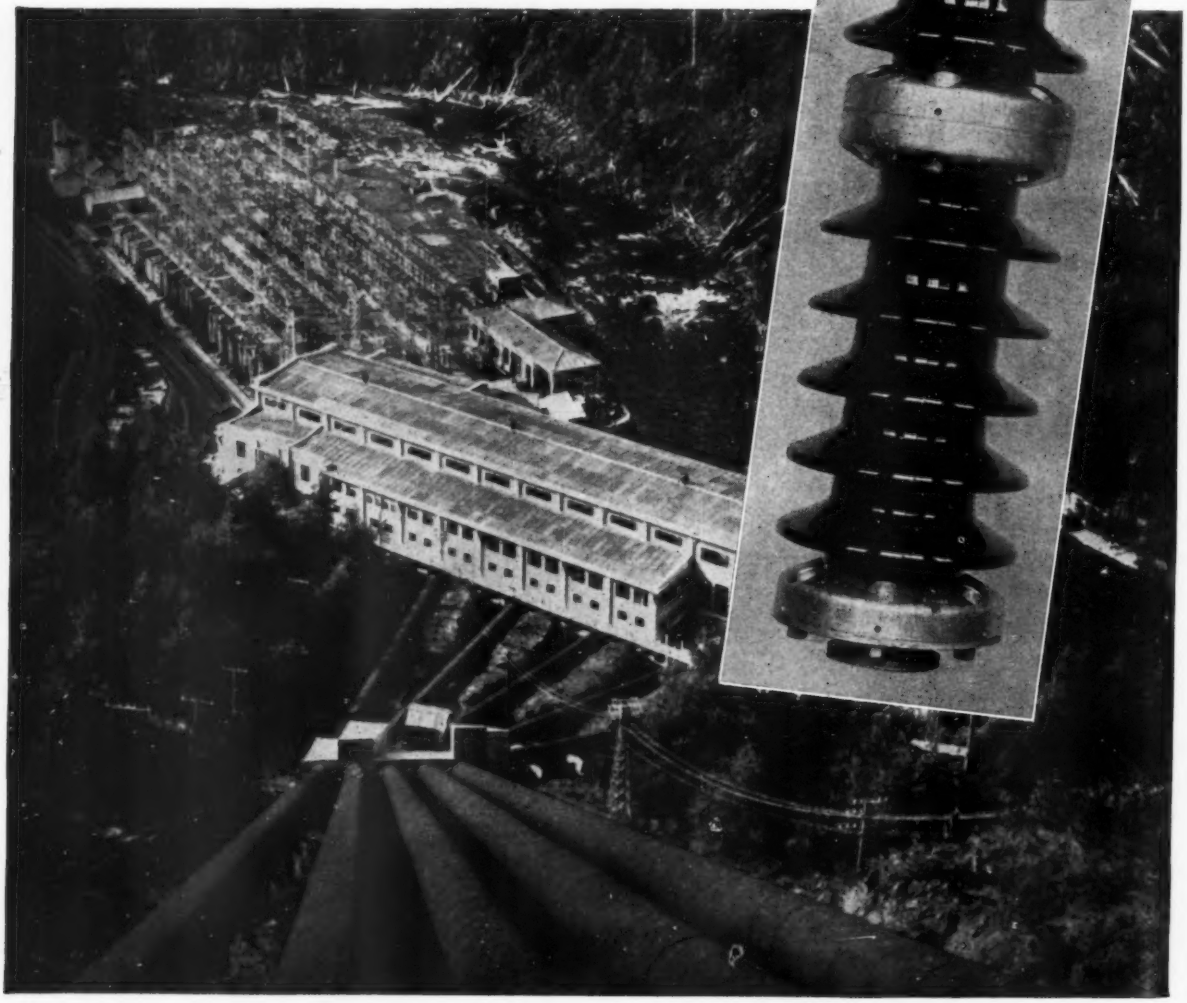
MAGRINI'S TRADE-MARK AND SWITCHGEAR WIN WORLD-WIDE RECOGNITION

MAGRINI S.P.A. - VIA L. MAGRINI 7 - BERGAMO - ITALY

S.P.P. Post Insulators

were used for the

Tarraleah Sub-Station, Tasmania



The Sub-station at Tarraleah, Tasmania, is one of the many 110 kV. and 88 kV. sub-stations on the Hydro-Electric Commission's system equipped throughout with S.P.P. Cylindrical Post Insulators.

STEATITE & PORCELAIN PRODUCTS LTD.

Stourport-on-Severn, Worcestershire Telephone : Stourport 2271 Telegrams : Steatain, Stourport

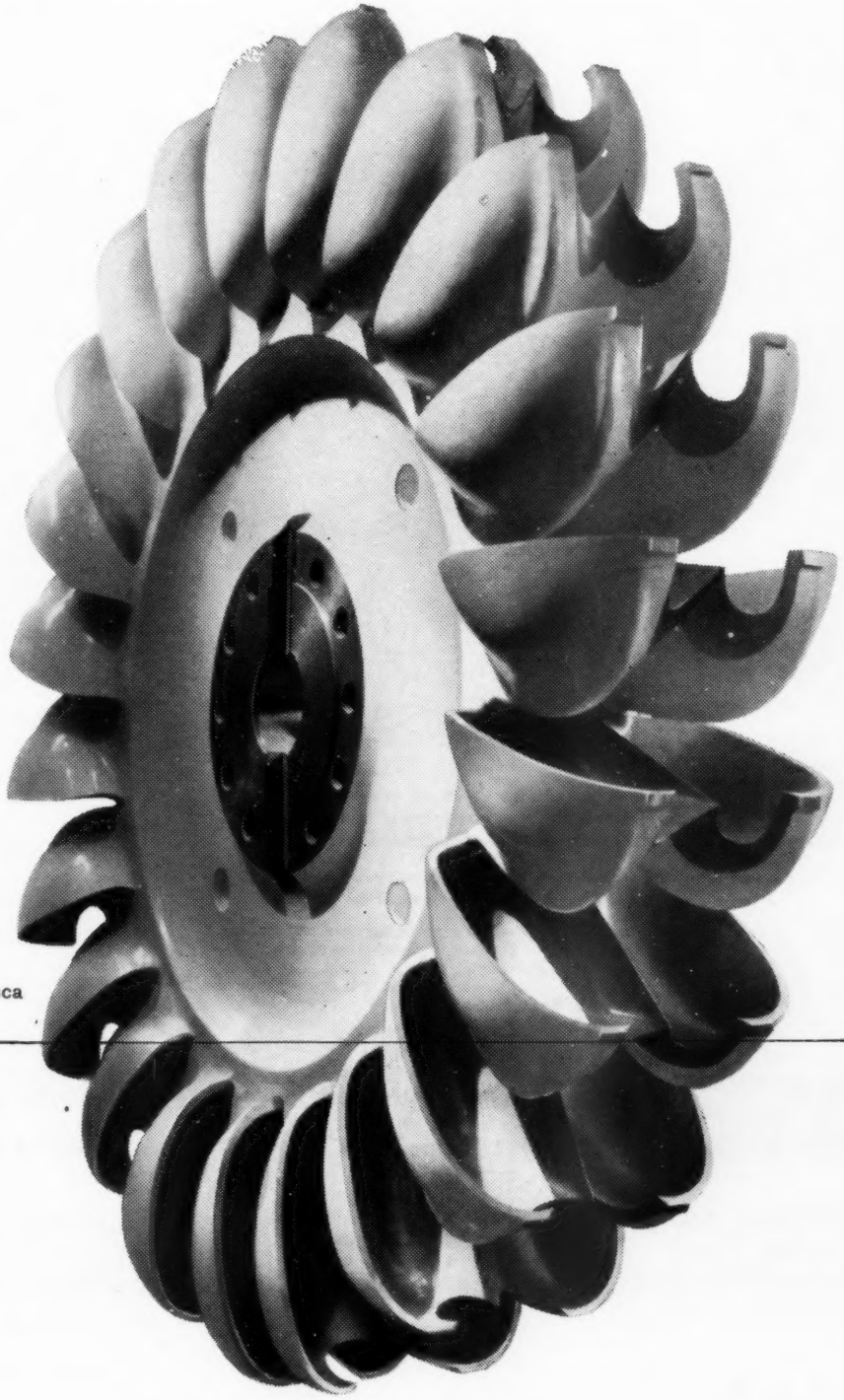
S.P. 80

ESCHER WYSS

has the following large impulse turbines in course of execution for Swiss installations

	Head in metres	Unit output HP
Castasegna	**710**	**45 000**
Loebbia	**730**	**47 000**
Tavanasa	**480**	**67 000**
Biasca	**700**	**110 000**
Tierfehd	**1030**	**125 000**

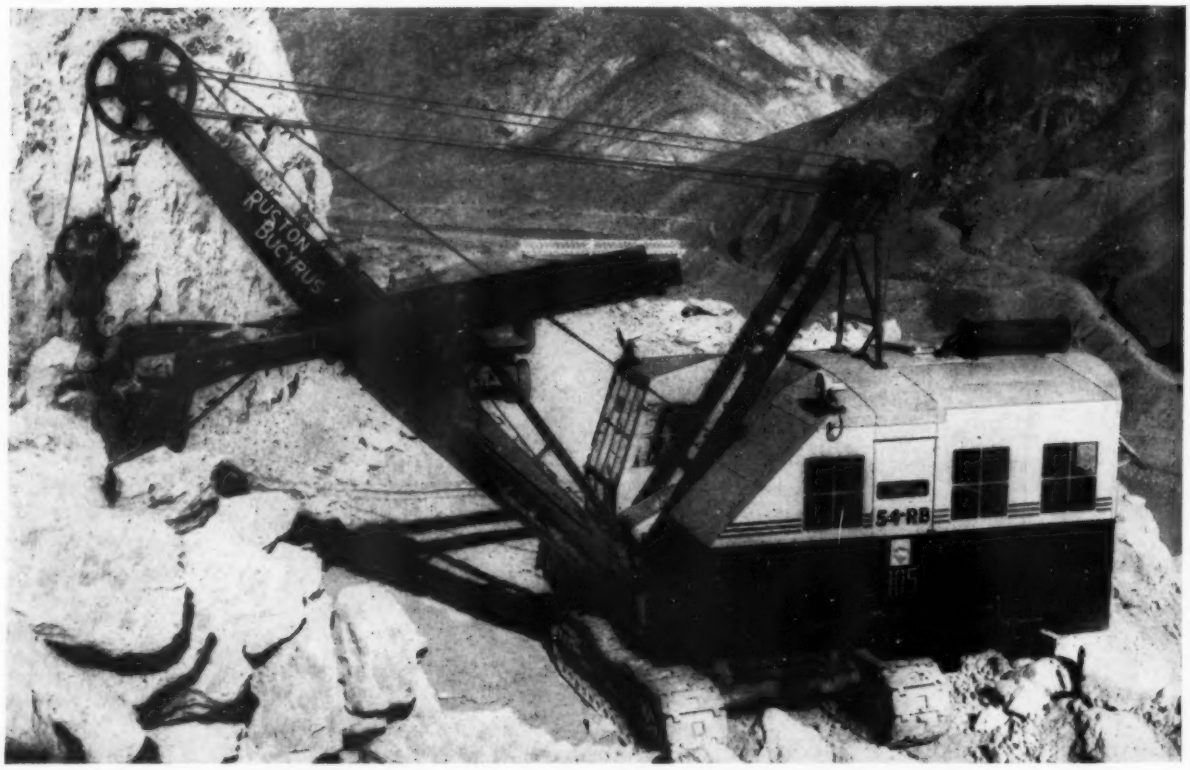
Escher Wyss Ltd., Zurich/Switzerland



One of the runners for Biasca

In the range of dependable Ruston-Bucyrus excavators

there is one which will serve your purpose best



In choosing a Ruston-Bucyrus excavator, irrespective of size or type, you will be sure of a machine that has been proved to give sustained high output at low cost combined with long life, even in the toughest work.

Examine the features of R-B machines which users and operators alike appreciate

Simple machinery layout for easy maintenance, adjustment and servicing.
Ball and roller bearings for smooth, efficient transmission of power.
Fast, easy-acting control to maintain high output.
Clutches and brakes of individual design and ample capacity for their duty.
Choice of mountings to achieve maximum stability for the specific operating conditions.
Easy conversion and equal efficiency with each front-end equipment.

Arid conditions in the mountains of Iran near the Caspian Sea emphasize the stamina of the Ruston-Bucyrus 54-RB. This 2½ cubic yard shovel, working an eighteen-hour shift, is engaged on the construction of the barrage for a hydro-electric scheme on the Sefid Rous River.

RUSTON-BUCYRUS

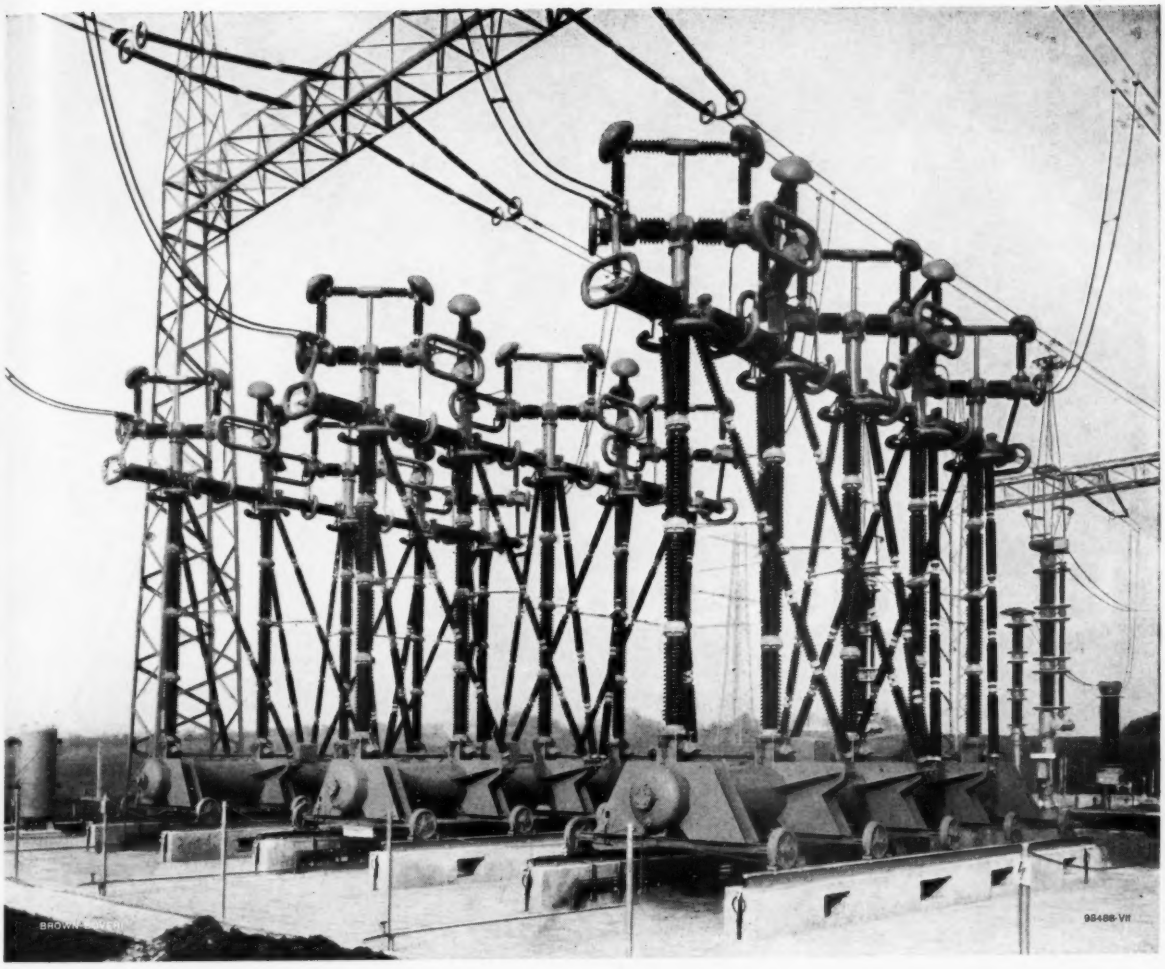
There is an excavator to suit you in the R-B range—3/8 to 6 cubic yards capacity

Write now for information on the size of the machine in which you are interested.

Ruston-Bucyrus Limited

EXCAVATOR SPECIALISTS, LINCOLN

R.B.1B



The first 380-kV transmission line

in the West German extra-high-voltage system of the Rheinisch-Westfälisches Elektrizitätswerk is equipped with

Brown Boveri air-blast circuit-breakers

in the two terminal stations at Rommerskirchen, near Cologne, and Hoheneck, near Stuttgart.

The illustration shows the 380-kV air-blast circuit-breakers at Hoheneck which were commissioned in 1957.

Brown Boveri transformers and air-blast circuit-breakers are also being supplied for the first Swiss 400-kV system of the Kraftwerke Hinterrhein AG., Thusis, Grisons. Air-blast circuit-breakers built by Brown Boveri have been operating in the Swedish and Finnish 380-kV transmission systems for some considerable time.

BROWN BOVERI

Products

for 400-kV operating voltage

Three - phase transformers with ratings up to 250 MVA

Three-phase banks of transformers comprising three single-phase units up to 660 MVA

Current and voltage transformers

Air - blast circuit - breakers with breaking capacities up to 20,000 MVA

Isolating switches

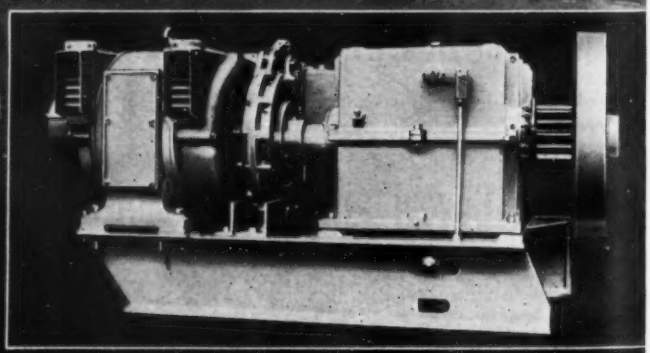
BROWN, BOVERI & CO., LTD., BADEN (SWITZERLAND)

Representatives in most countries.

Henderson

again leads the field in derrick crane design

Wherever there's engineering progress you'll find Henderson Derrick Cranes. The new Henderson Derrick cranes feature unit construction, enclosed gears, ball and roller bearings. Erection and dismantling is faster, control easier, vision better, running smoother and maintenance lower—items which add up to *reduced operating costs!*

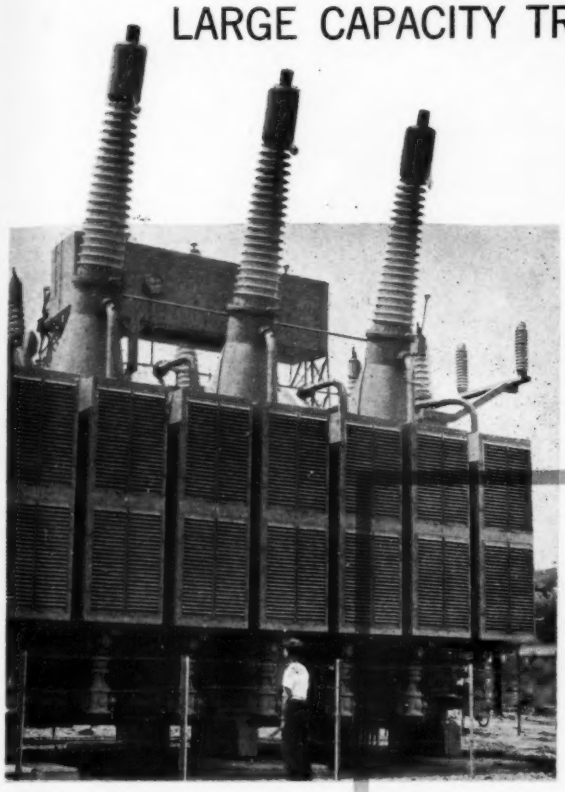


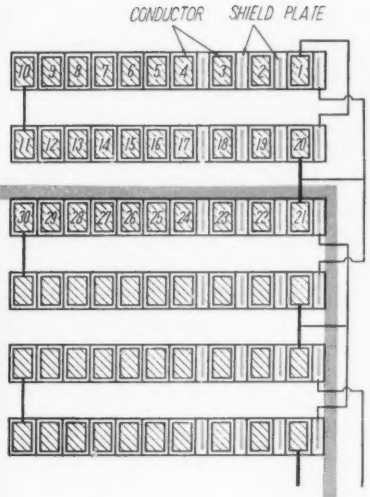
raising the standard of World Construction

JOHN M HENDERSON & CO LTD · KING'S WORKS · ABERDEEN · SCOTLAND

HITACHI

LARGE CAPACITY TRANSFORMERS





controsurge shielding improves performance

The Hitachi-designed Controsurge Shielding System consists of shielding conductors wound between the coil windings. The simplicity of the system permits shielding to be applied to inner windings as well.

The effective shielding greatly improves impulse voltage characteristics, and keeps potential distribution between each winding uniform.

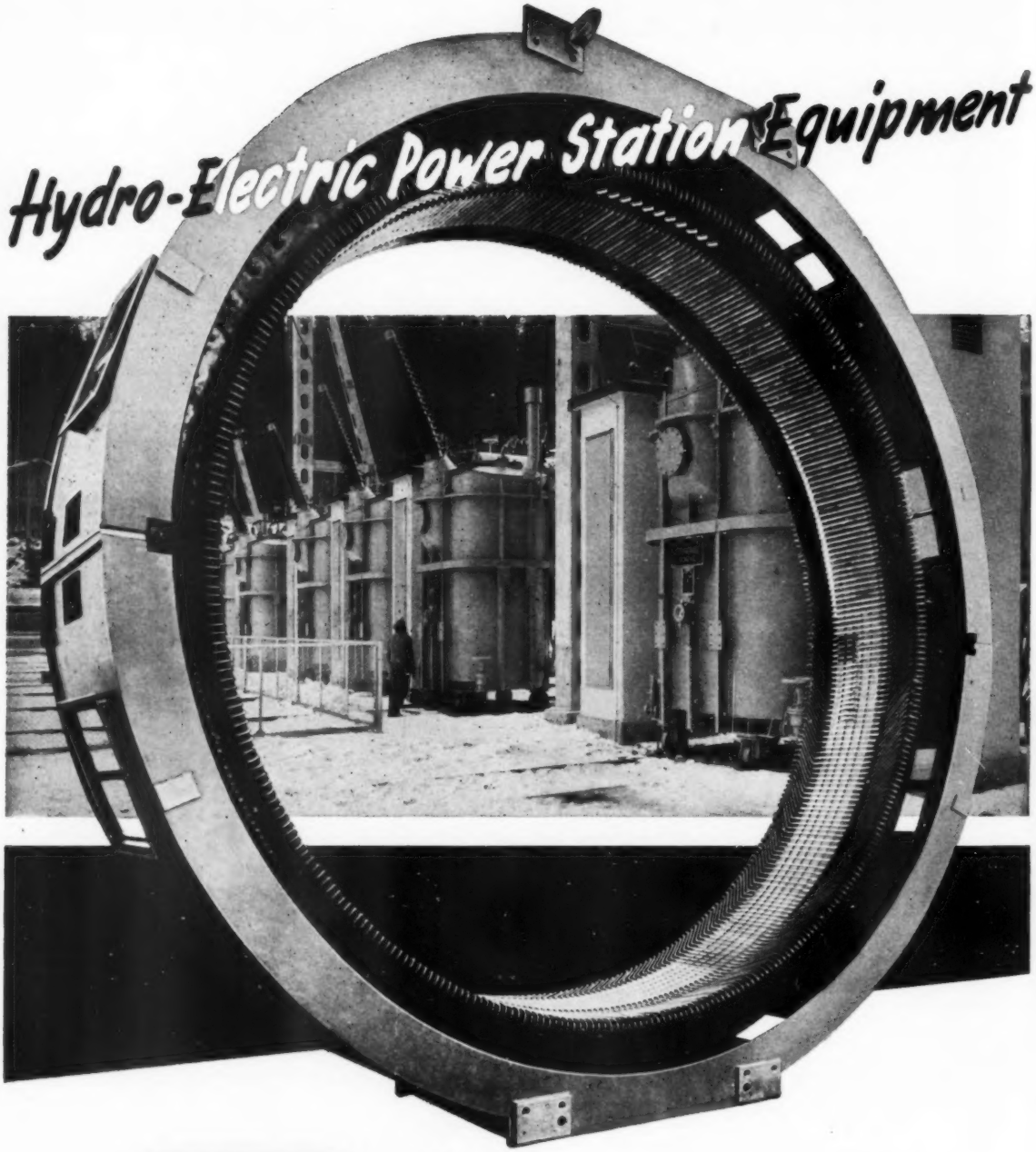
The unique system also reduces transformer size, resulting in lower initial cost and lower freight and cargo costs. Cooling characteristics are improved, because the shielding does not obstruct the flow of oil.

Units up to 100,000 kVA capacity, with completely assembled bodies and of reduced-height design, have been exported. We shall be pleased to send you detailed information on request.

Hitachi, Ltd.
Tokyo Japan

Supplying Japan's technology to the world

Hydro-Electric Power Station Equipment



Sécheron

Generators and motors with capacities above 150 kW. Single-phase and three-phase transformers for all outputs and voltages. Electrical applications in the field of traction. Installations of pumpless mercury arc rectifiers with rare gas filling. High-speed automatic regulators applied to various control problems. Welding rods and electric arc welding sets.

S.A. des Ateliers de Sécheron, Geneva

Top of Surge Shaft,
St. Fillans, Perthshire.
Consulting Engineers :
Sir M. MacDonald & Partners

800 feet deep

Part of one of the Hydro-Electric contracts entrusted to the Mitchell Construction Co. Ltd., the 28 ft. diameter Surge Shaft and 10 ft. diameter Penstock Shaft at St. Fillans which form a continuous vertical shaft 800 ft. deep. By employing a new and specially developed method of shaft raising, Mitchell Construction excavated the 600 ft. Penstock Shaft out of solid rock at an average rate of 64 ft. per week, with a maximum advance of 183 ft. in one week; such a rate of advance would have been impossible with the employment of conventional techniques on a shaft of this size.

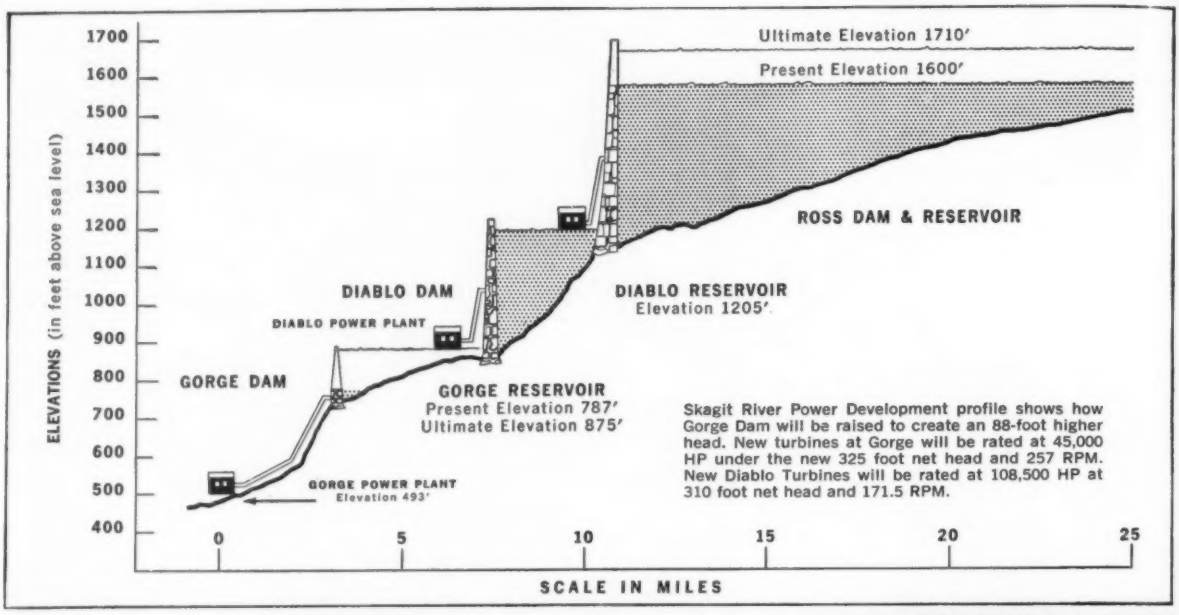
MITCHELL CONSTRUCTION

Building and Civil Engineering Contractors

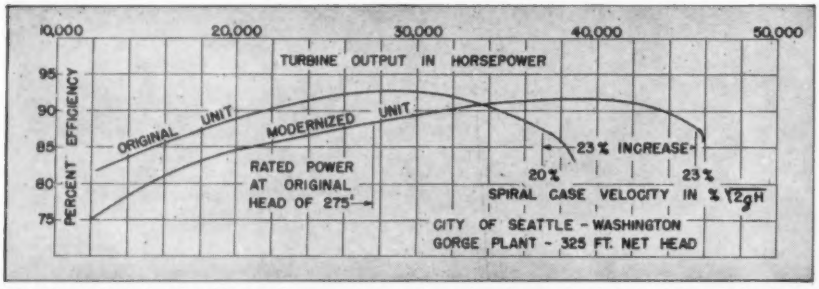
THE MITCHELL CONSTRUCTION COMPANY LTD

Wharf Works, Peterborough

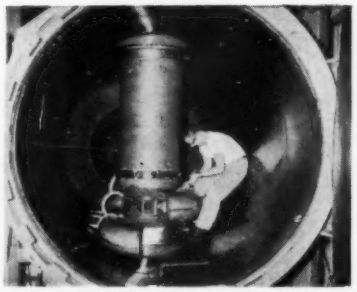
P.3050



Skagit River Power Development profile shows how Gorge Dam will be raised to create an 88-foot higher head. New turbines at Gorge will be rated at 45,000 HP under the new 325 foot net head and 257 RPM. New Diablo Turbines will be rated at 108,500 HP at 310 foot net head and 171.5 RPM.



This shows the Laboratory Test performance (power stepped up for head and size), of the existing Gorge runners under the higher head and the new runner and gate design for the same conditions.



A complete model of the Gorge wheel case assembly, built to extreme accuracy, is shown being mounted in the test chamber of the high-head test stand in York, Pa.

CITY OF SEATTLE TO GET MORE POWER

New Turbine Designs in Modernization of Gorge, Diablo Facilities Will Help Increase Capacity 23%

As part of its program to get more power, Seattle, Washington's Skagit River development includes replacement of 35- and 22-year-old turbine runners at the Gorge and Diablo plants, and increasing the height of the Gorge Dam. Rebuilt vertical Francis runners and new wheel case accessories will give each unit 23% more capacity in the existing wheel cases.

Extensive model tests, conducted in the Allis-Chalmers Hydraulic Division laboratory's high-head test stand, proved that the proposed new runner and modified gate designs would provide the increased power with very little loss in efficiency. In addition, they would have improved cavitation characteristics to permit maintaining the original setting above tailwater elevation.

Research results such as these indicate Allis-Chalmers can provide substantial economies in both new and existing installations with higher turbine speeds and settings as well as smaller spiral cases and inlet valves. For further information, write Allis-Chalmers Manufacturing Co., Hydraulic Division, York, Pennsylvania.

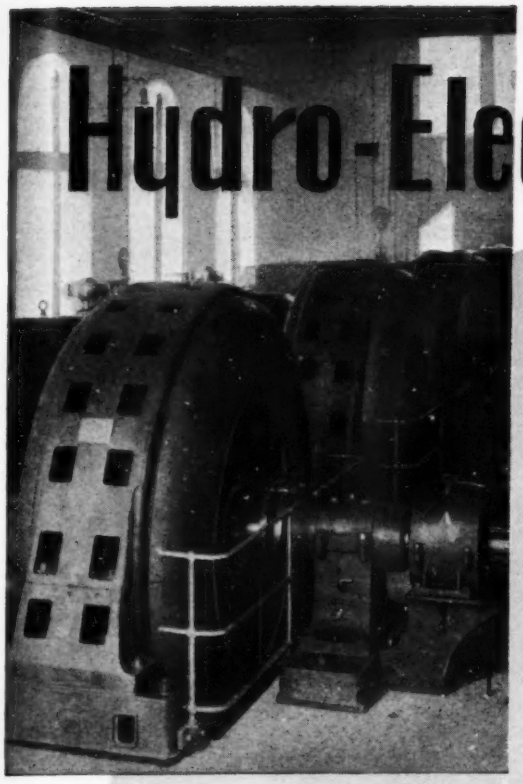
Since the Diablo units have gone into service, the city of Seattle advised that, prior to final testing, performance indicated that anticipated increase had been substantially met.

Hydraulic Division — RESEARCH · DESIGN · HYDRODYNAMICS · ENGINEERING · FABRICATION

Hydraulic Turbines & Accessories • Pumps • Liquid Heaters

Rotovalves • Ball Valves • Butterfly Valves • Free-Discharge Valves

ALLIS-CHALMERS

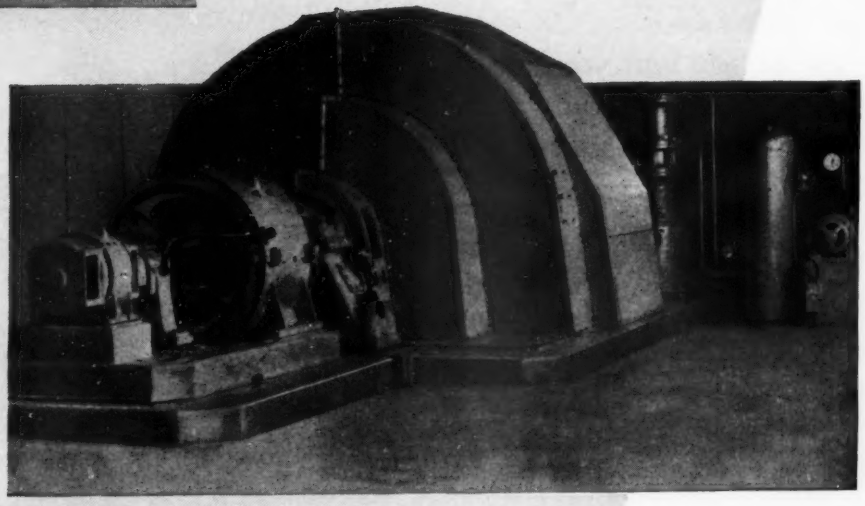


Hydro-Electric Generators

Fifty years ago Bruce Peebles engineered the Snowdon Hydro-Electric Scheme — from tunnelling to transmission lines—the first large project for public supply in Great Britain.

The original Cym Dyli Power Station, pictured at left, is equipped with four 1,500 kVA twin pelton wheel driven generators, which are still running.

These early generators were the fore-runners of the large machines being built to-day for service in many parts of the world.



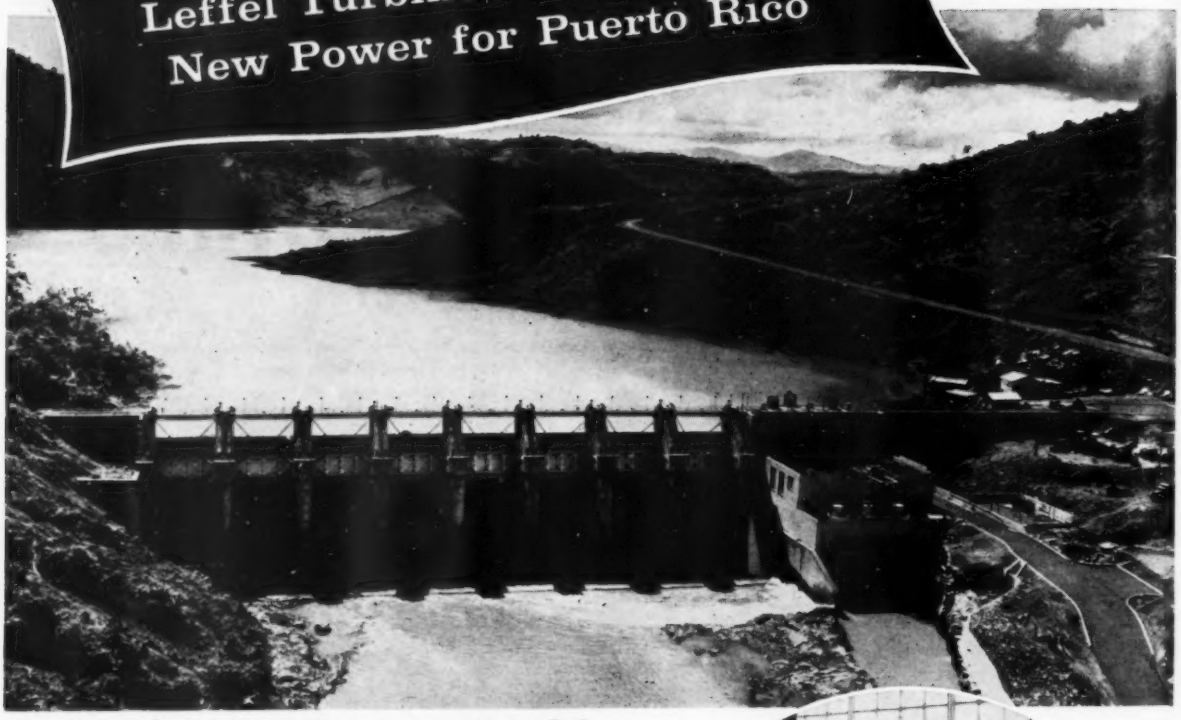
14,000 kVA hydro-electric generator installed in the Yksnelvane power station, Firdakraft, Norway.

Half a century has elapsed since the first Hydro-electric scheme was completed. The pioneering spirit is still dominant and is revealed to-day in the many contracts undertaken for large hydro-electric plant for many schemes at home and abroad. Ample resources for manufacture and testing enable the largest contracts to be undertaken.

BRUCE PEEBLES & CO. LTD., EDINBURGH, SCOTLAND

436a

Leffel Turbines Help Provide New Power for Puerto Rico



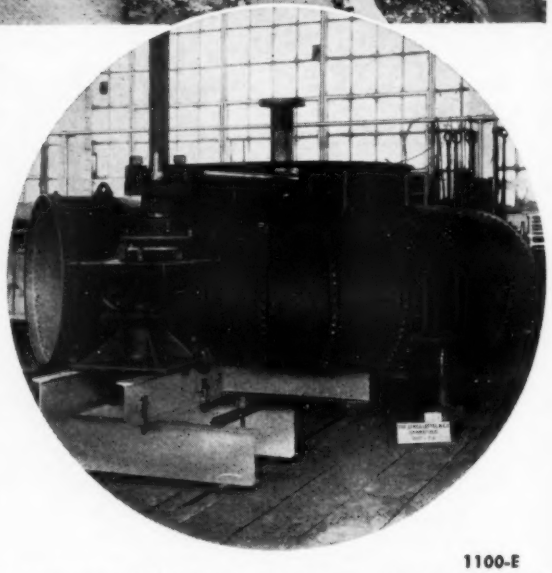
Rio Grande De Loiza Dam, a project of the Puerto Rico Aqueduct and Sewer Authority

At the new power plant at the Rio Grande De Loiza Dam, dependable Leffel turbines drive the generating units. Located at Trujillo Alto in San Juan's metropolitan zone, this project was constructed for adequate public water supply and hydroelectric power generation. It includes, in addition to the dam and hydroelectric plant, a filter plant and an extensive sanitation system.

Each of the three Leffel turbines in this station is rated to develop 1550 HP under 68 foot net head, speed 327 RPM. The view above shows the completed Rio Grande De Loiza Dam and hydroelectric plant. The view at the right shows one of the three plate steel spiral case turbine units being completed on the assembly floor of the factory.

Leffel turbines are dependably and efficiently harnessing water power all over the world as they are in Puerto Rico. Leffel designs and builds equipment for maximum reliability and efficiency — Leffel turbines last longer and do a better job because they're heavier and more rugged.

Leffel has been producing hydraulic equipment of the finest caliber since 1862. Before you plan your next turbine installation, whether it's completely new or the rehabilitation or expansion of present facilities write for the complete story. Our experienced engineers are ready to put their "know how" at your disposal . . . no obligation.



1100-E

THE JAMES LEFFEL & CO.

FOUNDED IN 1862

MORE EFFICIENT HYDRAULIC POWER FOR 97 YEARS

FREE CATALOG

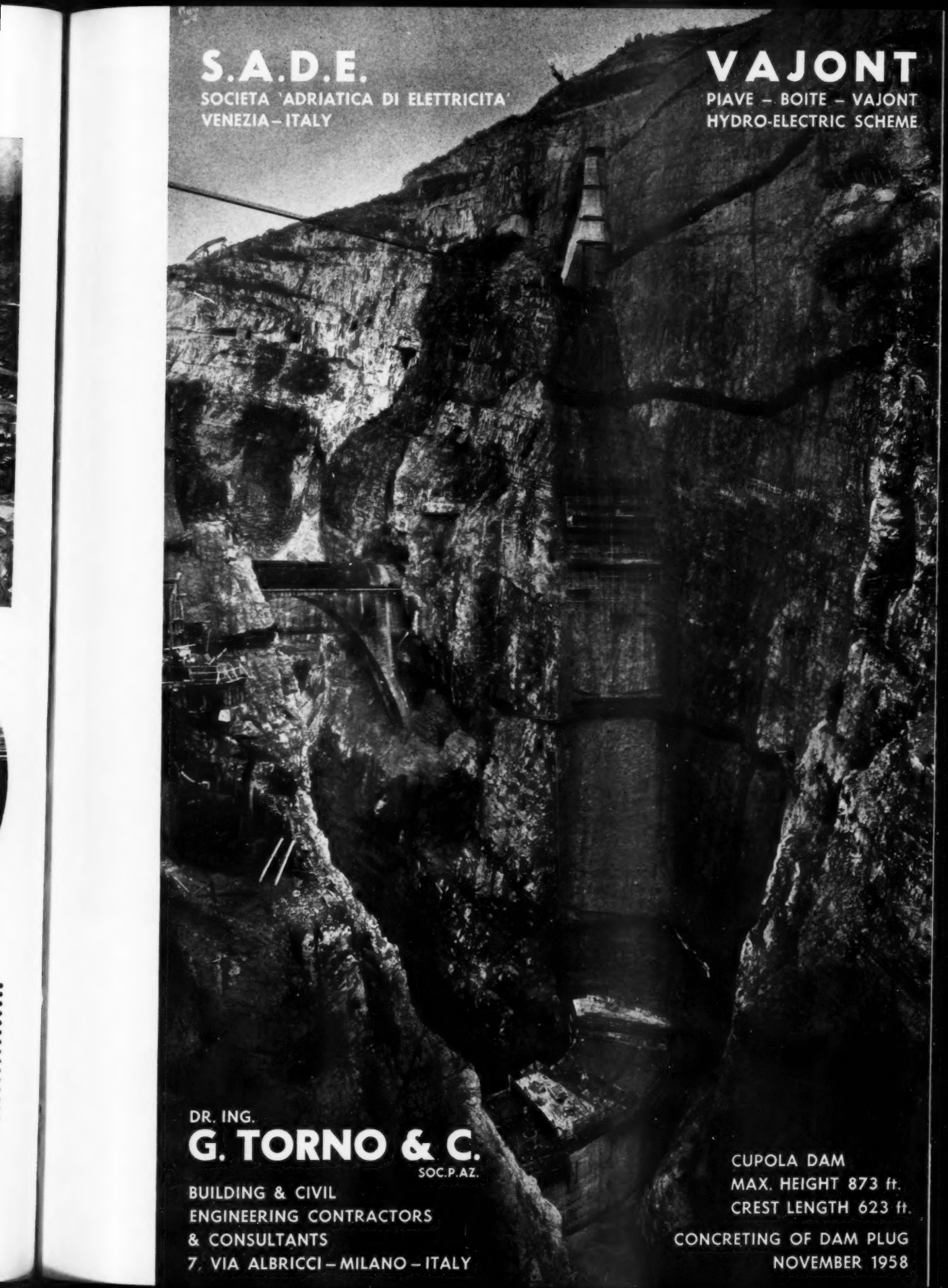
THE JAMES LEFFEL & COMPANY
Dept. W, SPRINGFIELD, OHIO

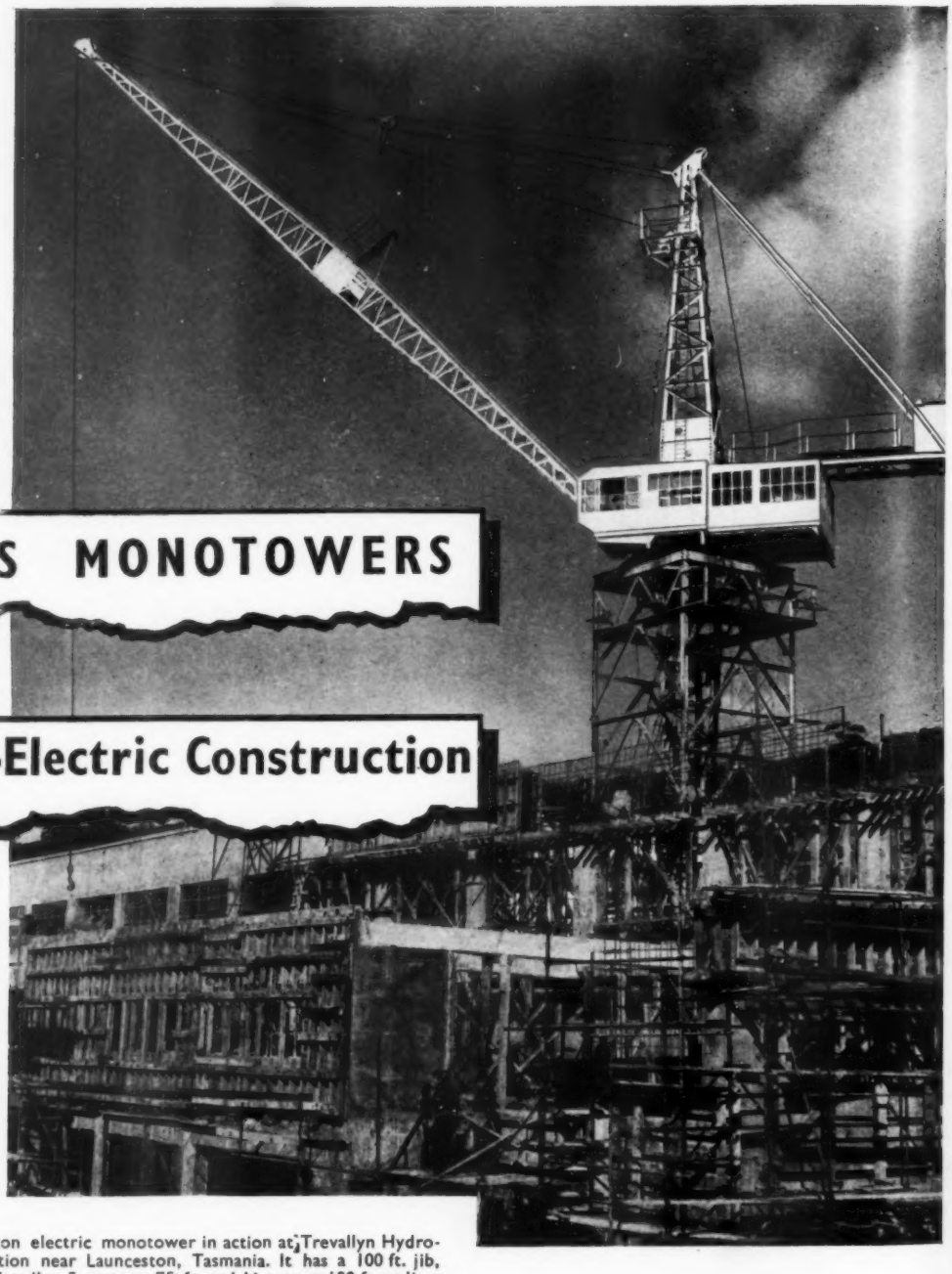
Please send me a bulletin on San Juan project and other descriptive literature on Leffel hydraulic turbines.

Name_____ Title_____

Company_____

Street_____ City_____ State_____


S.A.D.E.
SOCIETA 'ADRIATICA DI ELETTRICITA'
VENEZIA – ITALY
VAJONT
PIAVE – BOITE – VAJONT
HYDRO-ELECTRIC SCHEME
DR. ING.
G. TORNO & C.
SOC.P.AZ.
BUILDING & CIVIL
ENGINEERING CONTRACTORS
& CONSULTANTS
7, VIA ALBRICCI – MILANO – ITALY
CUPOLA DAM
MAX. HEIGHT 873 ft.
CREST LENGTH 623 ft.
CONCRETING OF DAM PLUG
NOVEMBER 1958



BUTTERS MONOTOWERS

in Hydro-Electric Construction

This crane is a 5 ton electric monotower in action at Trevallyn Hydro-Electric Power Station near Launceston, Tasmania. It has a 100 ft. jib, 80 ft. tower, and handles 5 tons at 75 ft. and 1¾ tons at 100 ft. radius. The ideal crane for erection of dams and high buildings generally, with all the dependability of the Butters product.

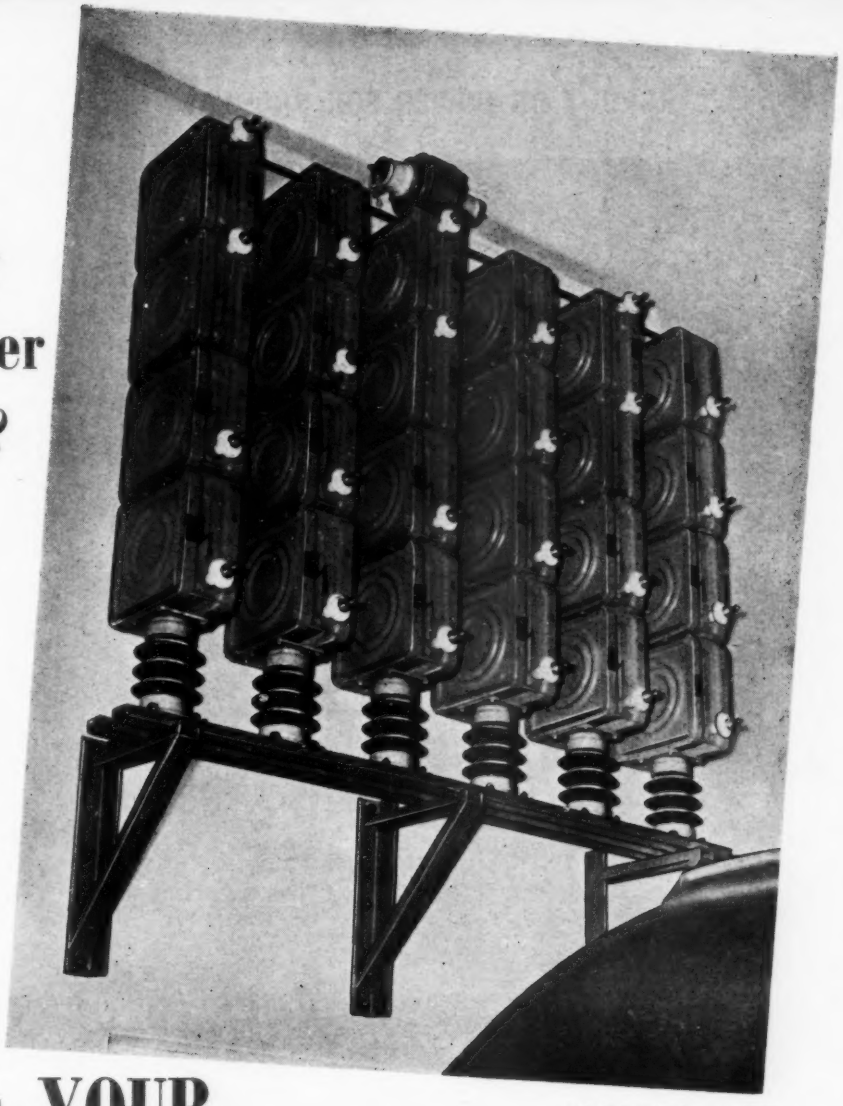
BUTTERS BROS. & CO. LTD.

MACLELLAN STREET, GLASGOW, S.1.

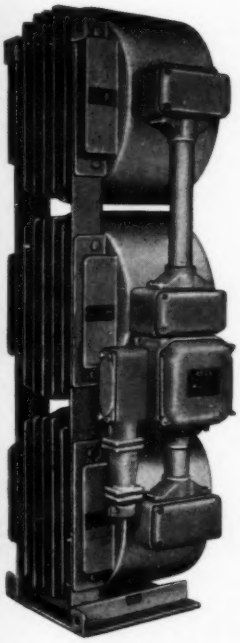
Telephone: IBROX 1141 (6 lines) *Telegrams: "BUTTERS, GLASGOW."*

AND AT LONDON, BIRMINGHAM & NEWCASTLE

Are YOU penalized for reactive power consumption?



Capacitor bank type CTD, 480 kVAr, 6·3 kV, 50 c/s, installed in a Norwegian pulp mill.



Capacitor type CTA, 87 kVAr, 400 V, 50 c/s, mounted in frame for fixing to wall or floor. Note the ample terminal enclosure.

Is YOUR electrical equipment being overloaded?

There is an unabating increase in the demand for electric power and many power supply systems are being worked to the point of failure.

ASEA Capacitors furnish an expedient and inexpensive means of improving your power situation.

The capacitors are designed as standard units which can be built up into banks of requisite size. Banks may be enlarged by adding units, or the rating altered by transferring units from one bank to another, according to prevailing supply conditions.

Consult ASEA for expert advice on your power problems. Capacitors in all sizes for 230, 400, 440 and 500—550 V can be supplied from stock.

ASEA Capacitors

- ★ **reduce all transmission losses**
- ★ **improve voltage conditions in the supply mains**
- ★ **permit higher active loading of generators, cables and transformers**
- ★ **enable the power producers to supply more kilowatts**
- ★ **entail lower costs for energy consumed**
- ★ **obviate penalties for excessive consumption of reactive power and energy**
- ★ **pay for themselves in a very short time merely by the reduction in penalties for reactive power**

Västerås ASEA **Sweden**

Aerial view of Ambuklao Power Station, largest hydroelectric installation in the Philippines. Inset picture shows underground power station housing 3 General Electric generators.

How a man-made lake and...

General Electric Helped Ambuklao Provide Low-Cost Power For The Philippines

Low-cost electric power is vital to the industrial and economic progress of all nations. In the Philippines, one big step forward has been the completion of the Ambuklao power station in Central Luzon. Here National Power Corporation's highly skilled team of engineers have harnessed the mighty Agno River with its history of flood and devastation, and made it into a peaceful lake that supplies the water for efficient hydroelectric power.

The unique underground power station at Ambuklao houses three General Electric hydro-generators which are a part of the system that provides a combined power output of 75,000 kilowatts. On the same subterranean level with the generator room is the control room where G-E switchboard panels are installed.

Other G-E contributions to the mammoth Ambuklao development include power transformers and carrier-current equipment. All of these products were designed, engineered, produced and tested to meet the highest standards of operating efficiency and reliability.

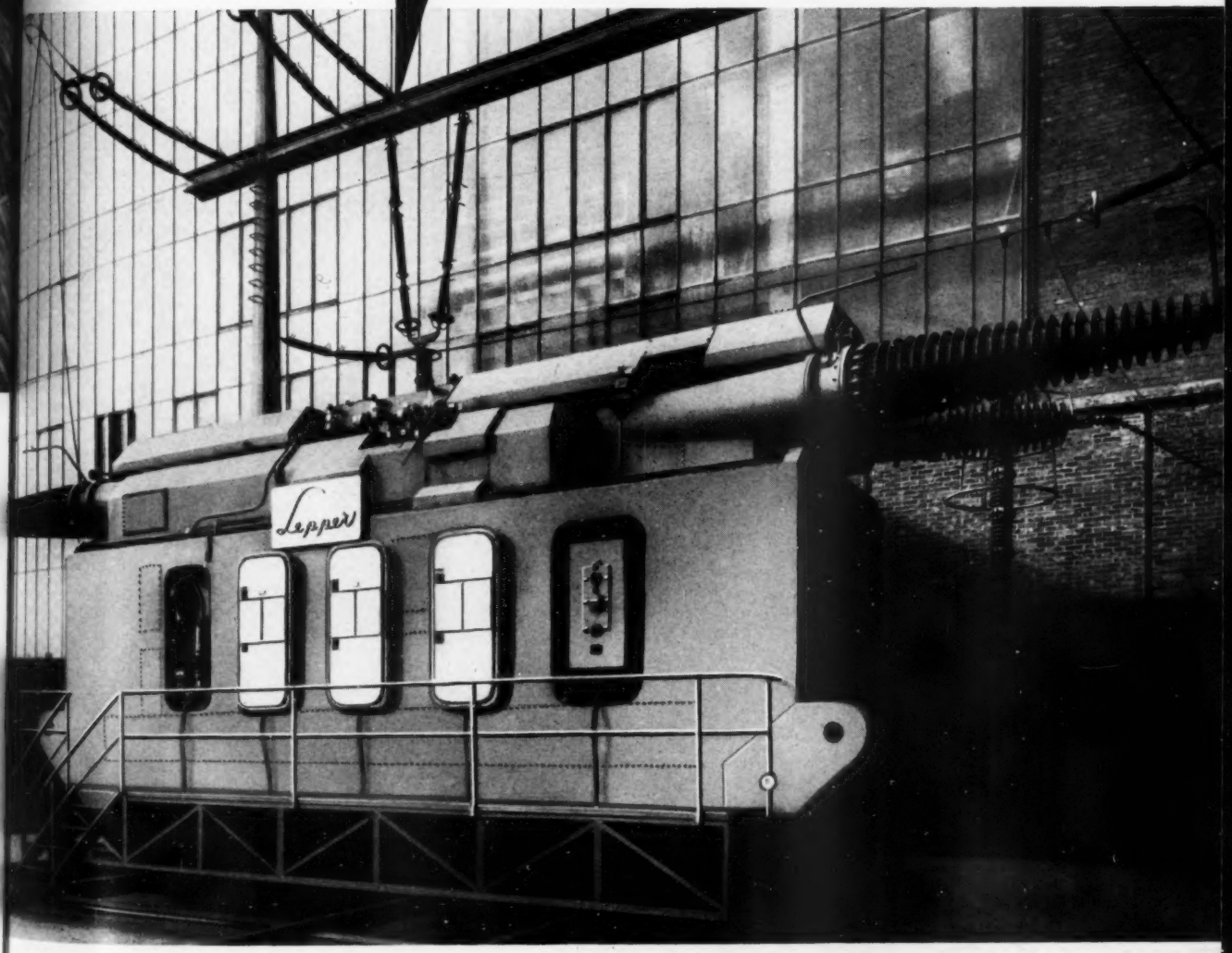
G-E with vast experience in the electric utility field has installed equipment, under the most adverse circumstances, that benefits government, industry and the people in countries all over the world. Contact your nearest G-E representative for full details about General Electric Power for Progress, or write: *International General Electric Co., Dept. 59-1, 150 East 42nd Street, New York 17, N.Y., U.S.A.*

GENERAL ELECTRIC
—U.S.A.—

90 MVA transformer with built-in tap changing gear, 245 ± 9 x 3 · 03/10 · 5 kV mobile with ON/OFF cooling.

Lepper

Transformers



Please visit us at the German Industrial Fair, Hanover, Hall 13, Stand 66/77, and our special stand in front of Hall 9.

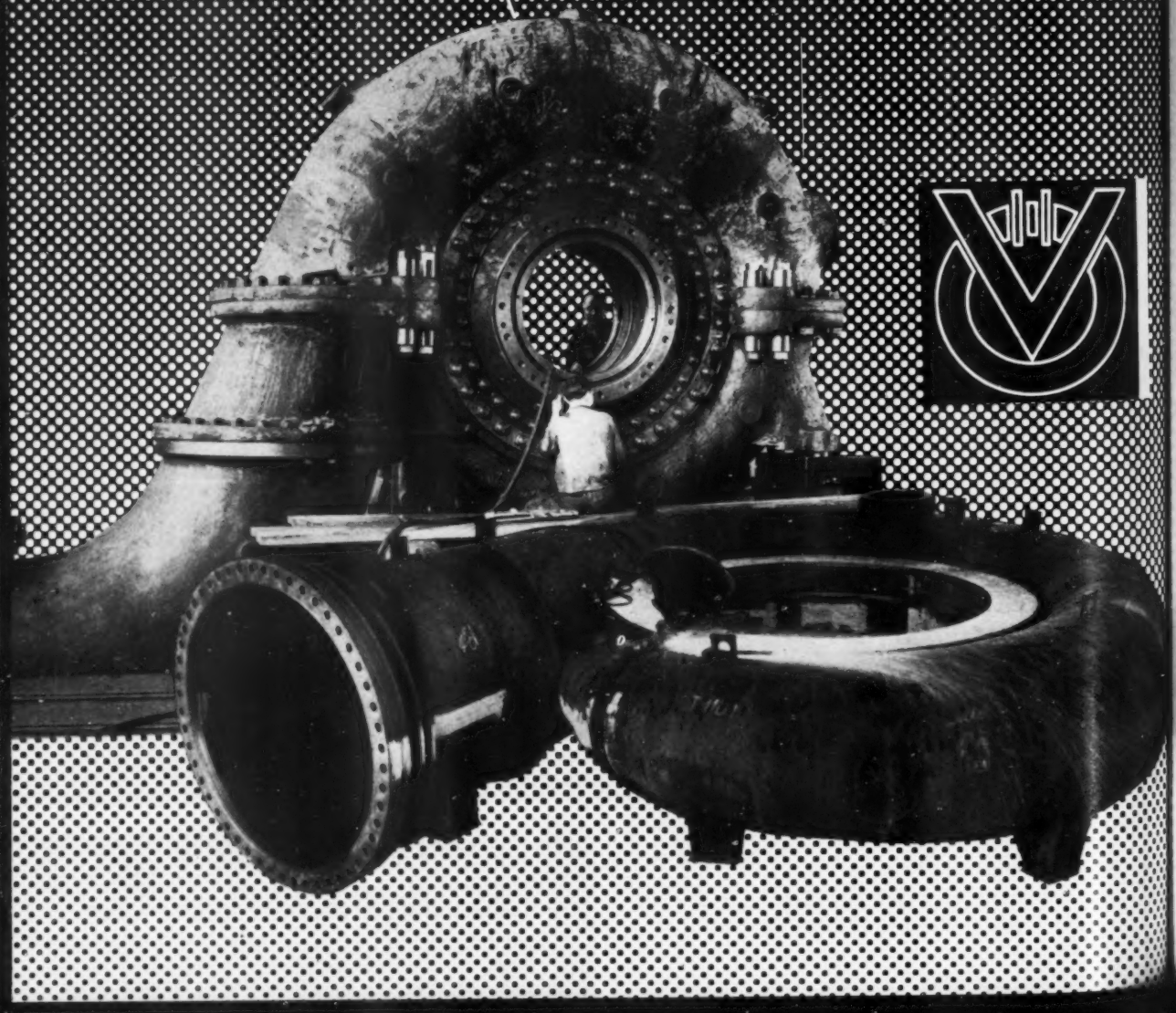
Transformatorenwerk August Lepper, Honnef/Rhein West Germany

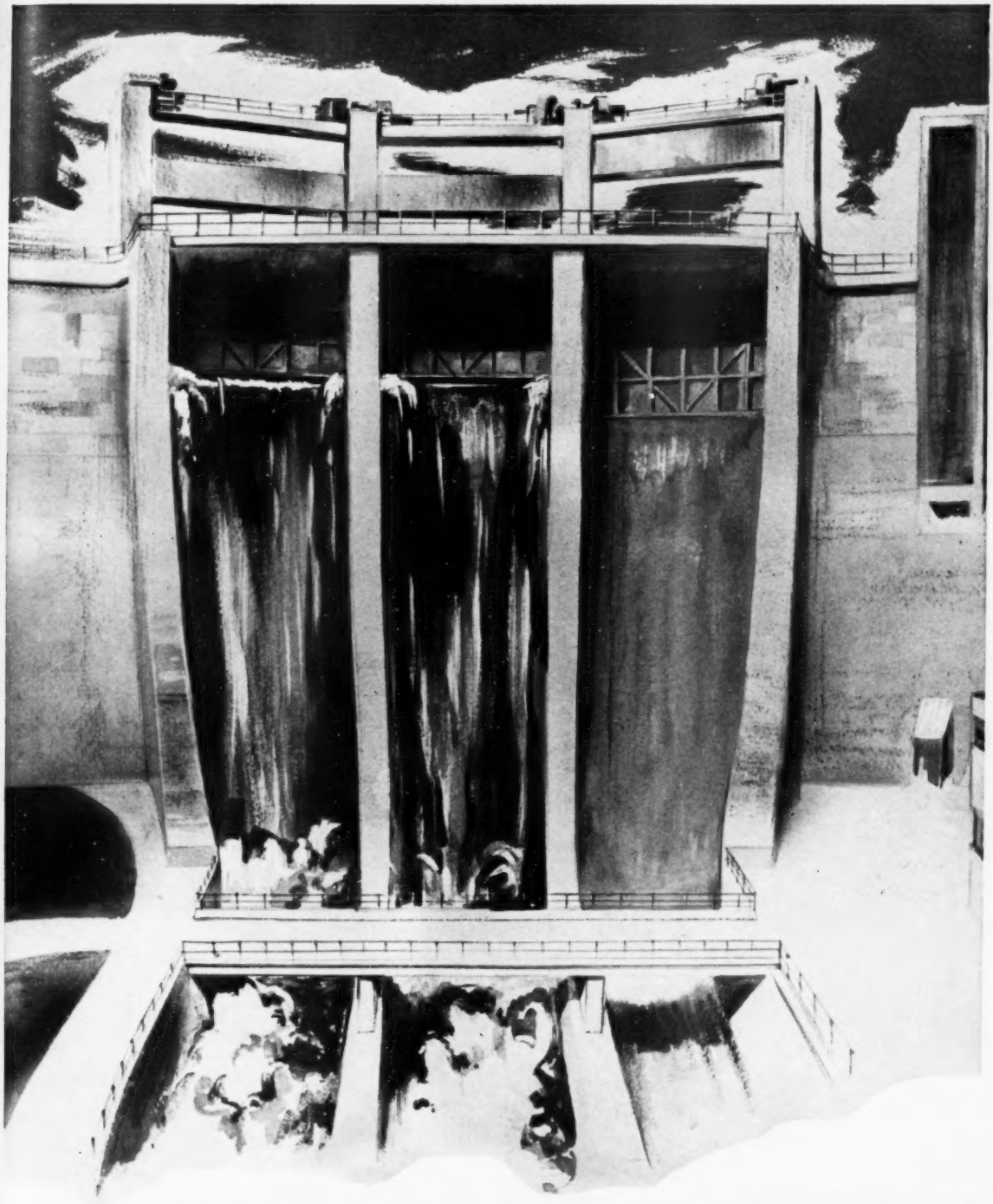
VÖEST

VEREINIGTE ÖSTERREICHISCHE EISEN- UND STAHLWERKE, LINZ-DONAU/AUSTRIA

Hydraulic Turbines, Spherical and Butterfly Valves

Licensed by Baldwin-Lima-Hamilton Corp.
Philadelphia, U.S.A.





TO DOUBLE THE POWER OF ROXBURGH

AEI

Four AEI waterwheel alternators at the New Zealand Electricity Department's Roxburgh Power Station are already feeding 160,000 kW into the South Island grid. Four additional sets, to bring the station up to its designed capacity of 320,000 kW, are now in course of construction.

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

HEAVY PLANT DIVISION — RUGBY AND MANCHESTER. ENGLAND

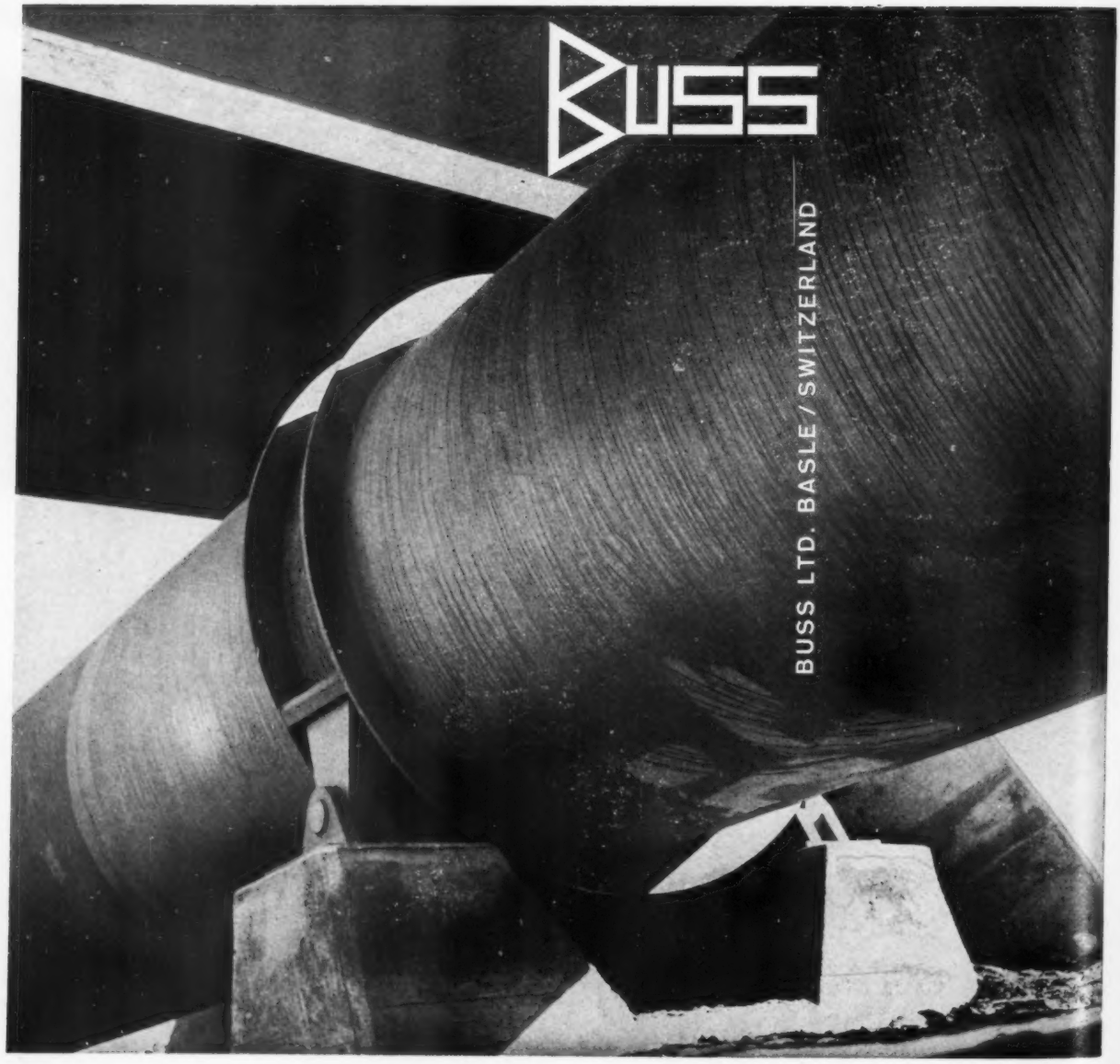
A 5379

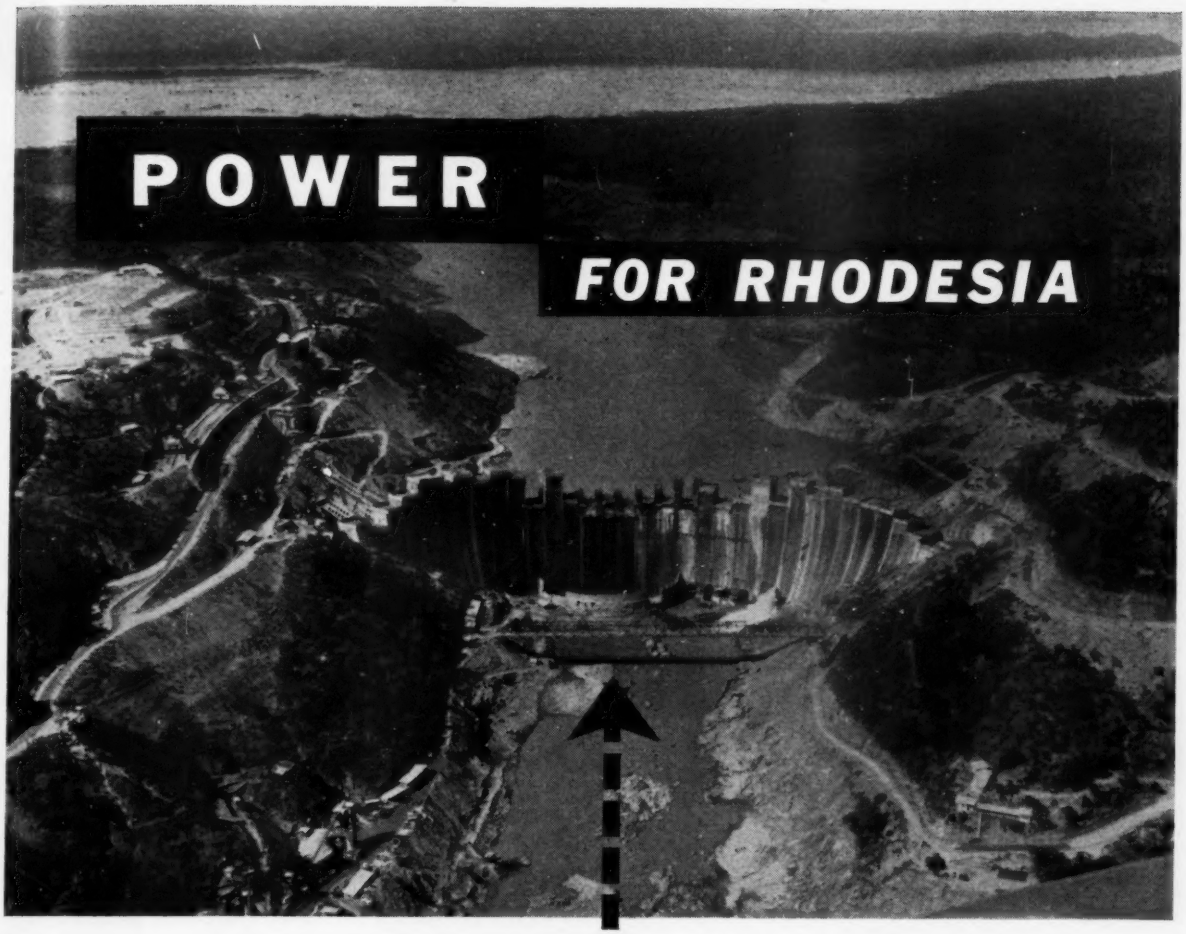
In the past few years we have manufactured and erected pipe-lines and tunnel reinforcements for the following hydraulic schemes:

Moyopampa (Peru)
Calancasca (Switzerland)
Kaftoun (Lybanon)
Châtelot (Switzerland)
Patla (Mexico)
Cavergno (Maggia, Switzerland)
Zongo (Belgian Congo)
Safien (Switzerland)
Vissoie (Switzerland)

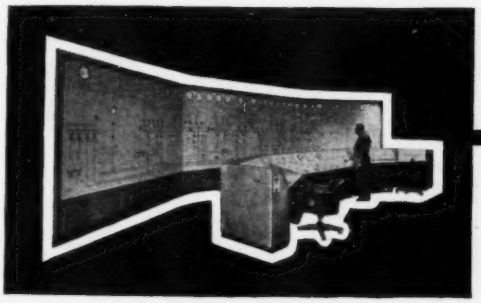
The following are still in execution:

Kiymbi (Belgian Congo)
Pontirone (Switzerland)
Göschenen (Switzerland)





S.T.C. Telecommunication & Control Systems for the Kariba Hydro-Electric Project



The rising structure of the new Kariba Dam on the Zambezi River indicates the immensity of this undertaking which will eventually result in the routing of electric power at 330 000 volts to the 'copper belt' towns of Northern Rhodesia and the major cities of Southern Rhodesia.

S.T.C. are supplying and installing equipment which will control and supervise transmission lines involving a total length of 935 miles. This will include Voice Frequency Telegraph equipment, Remote Control and Remote Indication equipment, Remote Metering equipment, Teleprinter equipment, Photo-facsimile equipment and Telecommunication equipment. Power Line Carrier equipment is also being installed by S.T.C. whose unequalled experience in Remote Control and Indication Systems, a deciding factor in the award of the Kariba contract, is available to Electricity Undertakings all over the world. Ask to see the Company's specialist engineers at the planning stage.

ELECTRONIC SYSTEMS GROUP

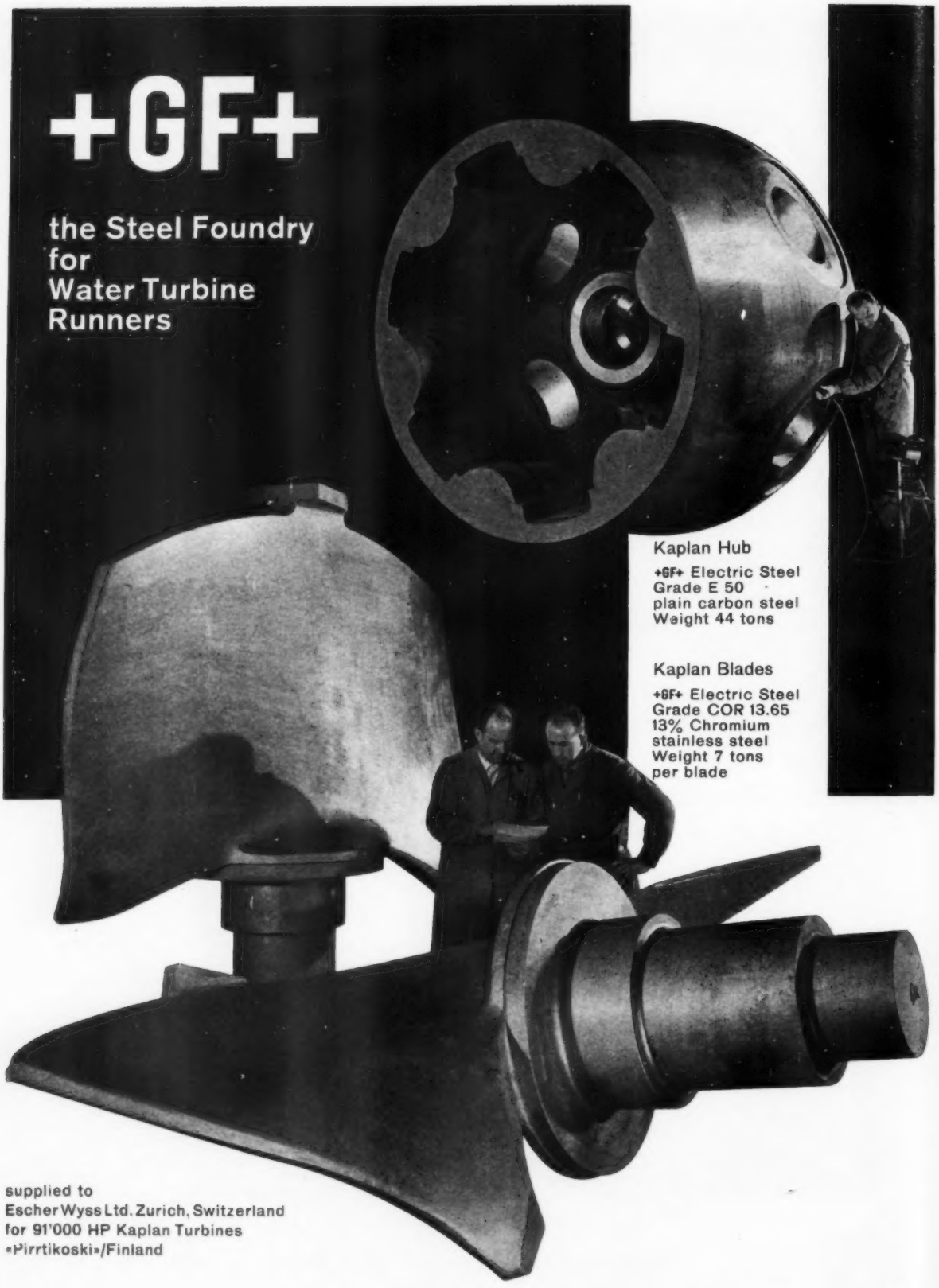
Standard Telephones and Cables Limited

Registered Office : Connaught House, Aldwych, London, W.C.2

TELEPHONE DIVISION: OAKLEIGH ROAD · NEW SOUTHGATE · LONDON N.11

+GF+

the Steel Foundry for Water Turbine Runners



Kaplan Hub

+GF+ Electric Steel
Grade E 50
plain carbon steel
Weight 44 tons

Kaplan Blades

+GF+ Electric Steel
Grade COR 13.65
13% Chromium
stainless steel
Weight 7 tons
per blade

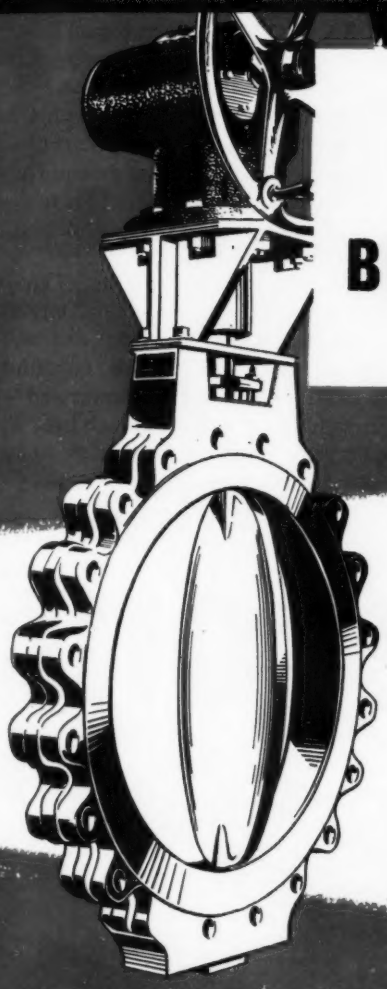
supplied to
Escher Wyss Ltd. Zurich, Switzerland
for 91'000 HP Kaplan Turbines
«Pirrtikoski»/Finland

George Fischer Limited, Schaffhausen, Switzerland

Telephone: (053) 56031 / 57031 Telegrams: Geofischer

Sg 710/4

NOW manufactured in Britain

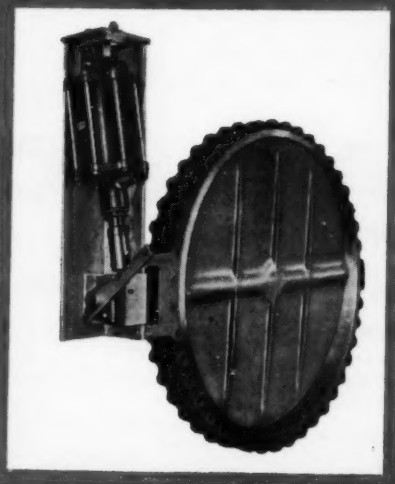


COCKBURN-ROCKWELL
HEAVY-DUTY
BUTTERFLY-VALVES
including WAFER-DESIGNS

Rockwell Heavy Duty Butterfly Valves are now manufactured under licence in Britain by Cockburns of Cardonald

These Valves provide wedge-tight shut off for steam, gas or fluid at pressure differential up to 150 p.s.i.

- **Positive Control for a wide range of applications.**
- **Easy installation with small face-to-face dimensions.**
- **Low first cost.**
- **Wide range of operating mechanisms.**
- **Made of any metal with any lining, for any operating pressure, temperature and flow conditions.**
- **Minimum restriction to flow and pressure drop.**
- **Rigid shakeproof assembly eliminates vibration and friction.**



42" Wafer Butterfly Valve with pneumatic operation. Suitable for Public Utility installations.

COCKBURNS LIMITED
CARDONALD GLASGOW S.W.1
London Office: 175 Piccadilly, W.1
N.E. Depot: Fish Quay, N. Shields

4ft in 75 seconds

4ft. in 75 seconds! That was the speed of penetration in trials with the new CP "TORNADO" lightweight tunnel drill, carried out in hard limestone having an average crushing strength of 29,000 lb.sq.in.
This outstanding performance, with a feedleg-mounted drill under 50 lb. in weight, is the outcome of an entirely new design, featuring a short-stroke 3″ diameter piston, re-designed air-flow passages in the valve and other improvements.
Different drilling conditions do, of course, provide variable performances. Only a trial can reveal how the "Tornado" drill will perform under your particular conditions.
You must be interested in power like this with the advantages of such light weight equipment, so use the form below to arrange a demonstration on your own site.

... with a machine of only 50 lb.

TORNADO

No. 503 ROCK DRILL

Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO. LIMITED, DAWES ROAD, LONDON, S.W.6.

To CONSOLIDATED PNEUMATIC TOOL CO. LTD., Dawes Road, London, S.W.6.

Please send details of, and arrange to demonstrate, the C.P. "Tornado" rock drill to.

NAME.....

ADDRESS.....

.....

40

CP.161

★ The illustration shows a Horseley - Piggott Pressed Steel Tank which was supplied to the Dearne Valley Water Board.

HORSELEY GROUP

The Horseley Group offers a wealth of experience and extensive facilities to meet the most exacting demands of Constructional, Chemical, Civil, Gas and Water Engineering.

The **HORSELEY** *Group*

HORSELEY BRIDGE & THOMAS PIGGOTT LTD
TIPTON · STAFFS
Telephone: Tipton 1104

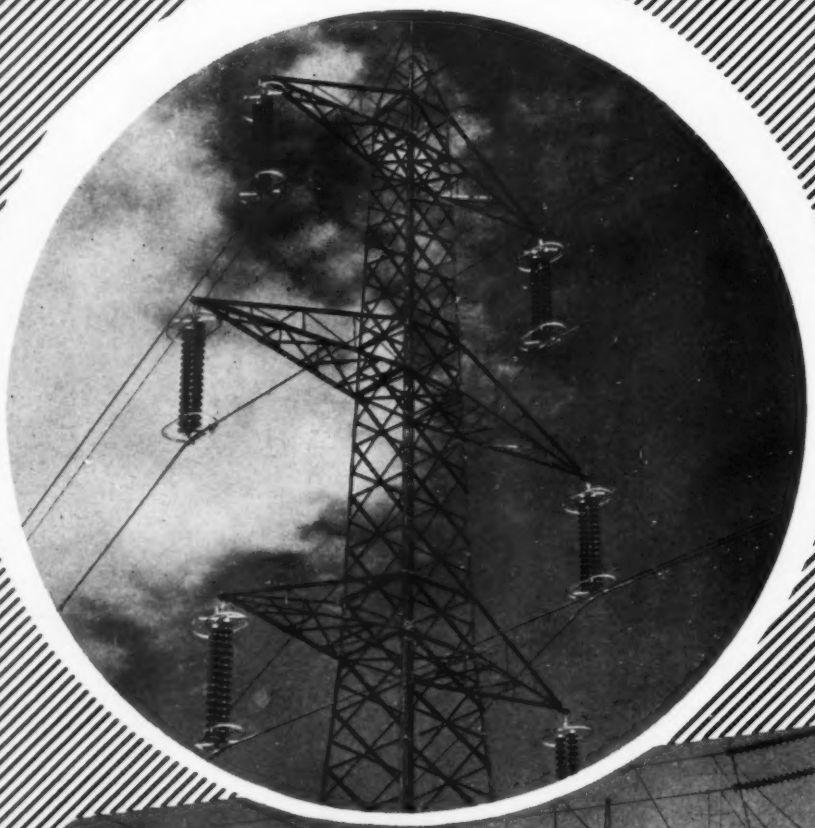
•

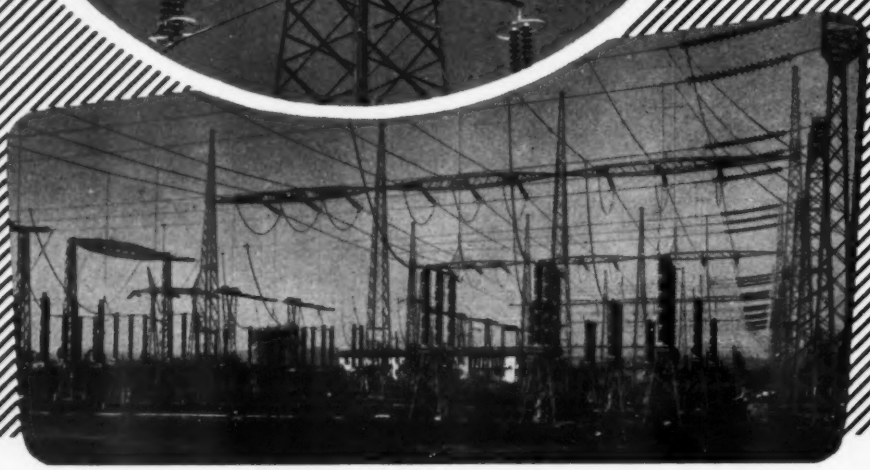
MECHANS LIMITED
GLASGOW
and Associated Companies

•

Also at
LONDON · SHEFFIELD
NEWCASTLE WADDON

SALVI





For 30 years Messrs. A. Salvi and Company, Milano, Italy, have specialized in the design and manufacture of complete equipment for Overhead Transmission Lines, including Compression Dead End Assemblies and Joints.
The Works of the Salvi Company are engaged exclusively in the production of high grade fittings for High Voltage Transmission Systems, up to and including voltages of 220/380 KV and for all sizes of Copper, A.C.S.R. and Aluminium Alloy Conductors.

SOLE REPRESENTATIVES IN THE UNITED KINGDOM AND THROUGHOUT ALL DOMINION COUNTRIES (EXCEPT AUSTRALIA AND NEW ZEALAND) AND BRITISH COLONIES AND PROTECTORATES

THE ENGLISH SALVI COMPANY LTD., 11 Kensington Church St., London, W.8

Telephones: WEStern 8857 and 4412 Cables: ENSALVICO LONDON

as one contractor to another—

the best in the field

Ingersoll-Rand

air equipment

BRITISH MADE

For full details and literature write to

INGERSOLL-RAND CO LTD 165 QUEEN VICTORIA ST LONDON EC4 TEL CEN 5681

SCOTTISH OFFICE 20 RENFREW ST GLASGOW C2 TEL DOUGLAS 1233 GRAMS INGERSOLL GLASGOW

P627

SIEMENS

1/124 E

Hydroelectric Power in Finland

We are supplying 2 generators with the following data for the Pirttikoski power station* in North Finland

70,000 kVA · 115.4 r. p. m. · 13,800 V

Stator bore 8.4 m (27′–6½″) · Total weight 500 tons

* See the report in Water Power, March 1959

SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT

BERLIN · ERLANGEN

WATER POWER

A technical journal devoted to the study of all aspects of hydro-electric development

Annually 40 shillings by post. Single Copies 2s. 6d.

Volume 11 Number 5

CONTENTS FOR MAY, 1959

Editorial: Power in the Common Market - - 161

Editorial Notes - - - - - - 162

Correspondence: Bolted Angle Struts - - - 164
By R. Mercier

Book Reviews - - - - - - 165

Chute-des-Passes Project - - - - 166

Leakage in Butterfly Valves - - - - 175
By S. N. Vinze, B.E. (Elec.) (Bom.), M.S. (Calif., U.S.A.), Mem.A.I.E.E. (U.S.A.), A.M.I.E. (Ind.)

Model Investigations on Bolted Angle Structures - 178
By M. Gregory, B.E., A.M.I.C.E., A.M.I.E. (Aust.)

Picote Station—II - - - - - 183

Smooth Blasting - - - - - 189
By Ulf Langefors

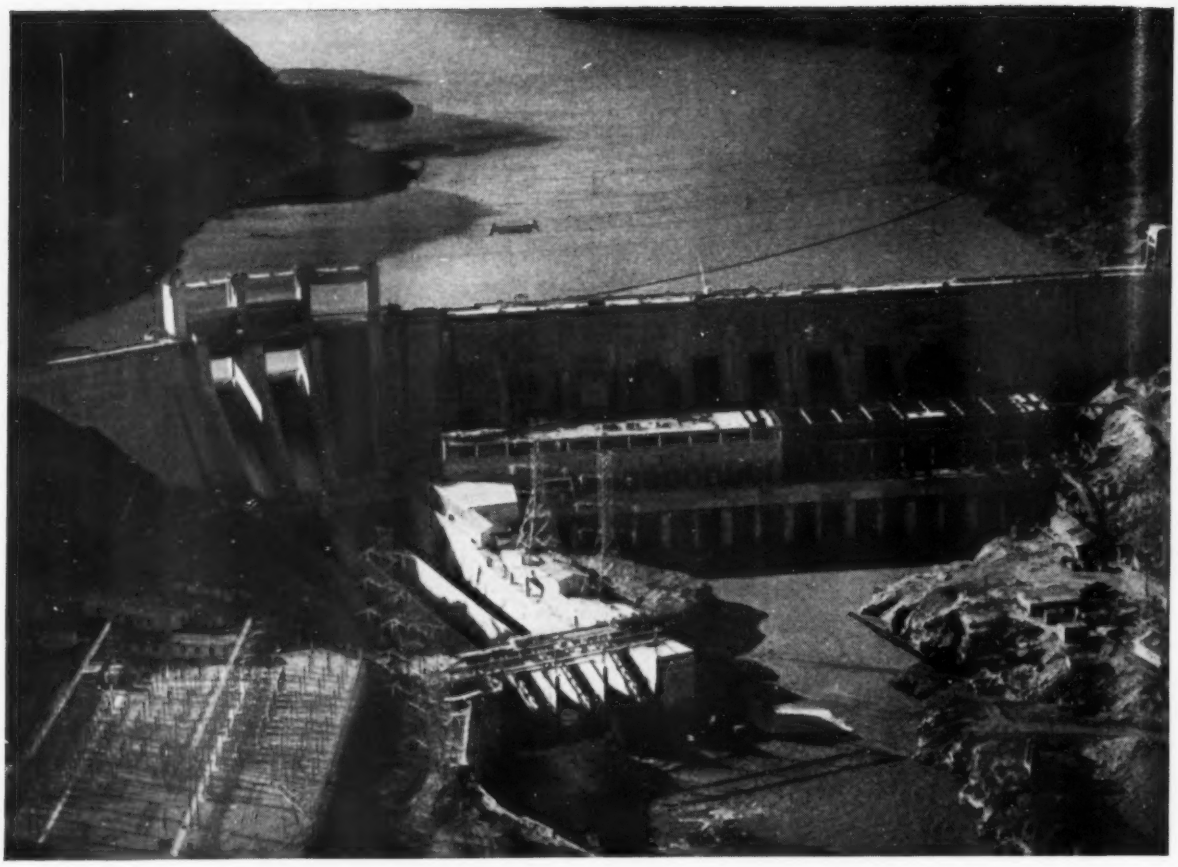
Short Articles: Diesel Engine for Up-country Service—Alternators for Karnafuli—Cantilever Shuttering - 195

Abstracts from the World Technical Press - - 198

Editor : H. STOREY, M.C., B.Sc., M.I.M.E.

PUBLISHED BY TOTHILL PRESS LIMITED
33 Tothill Street, Westminster, London, S.W.1
Telegrams: Trazette, Parl, London. Telephone: Whitehall 9233 (20 lines)

MANCHESTER: Century Insurance Building, St. Peter's Square. Telephone: Central 7667/8/9
BIRMINGHAM: 90 Hagley Road, Edgbaston. Telephone: Edgbaston 2466
NEWCASTLE-ON-TYNE: 21 Mosley Street. Telephone: 22239
GLASGOW: 139 Bothwell Street. Telephone: Central 4646
LEEDS: 70 Albion Street. Telephone: 27174
BRISTOL: 20 Victoria Square. Clifton. Telephone: Bristol 33873



New power for a Dominion from the Roxburgh Hydro-Electric Project

New Zealand's largest hydro-electrical undertaking, the Roxburgh project, will eventually feed an additional 320,000 kilowatts of electricity into the South Island grid system. The 1,200 ft. Dam, which is the largest ever built in the Dominion, was completed far ahead of schedule by Cubitts' New Zealand Co., in association with Conrad Zschokke Ltd., Geneva, and Downer & Co. Ltd., New Zealand.

This is one of many examples where the experience of the Cubitt Group of Companies is helping in the development of overseas territories.

THE CUBITT GROUP OF COMPANIES
UNITED KINGDOM AND OVERSEAS

With the experience of the past

CUBITTS

BUILD FOR THE FUTURE

HOLLAND & HANNEN AND CUBITTS (GT. BRITAIN) LTD · ONE QUEEN ANNE'S GATE · LONDON SW1

C219

WATER POWER

A technical journal devoted to the study of all aspects of Hydro-Electric Development

Power in the Common Market

ANY truly international journal has an important function to fulfil, not only in pointing out technical progress, but also in discussing significant changes in the economic field. From the beginning of mankind, life and livelihood have depended on energy in one form or another and our prosperity in the future will be no less dependent on increased quantities of power produced economically at the right time and place. Those whose responsibility it is to plan for estimated power requirements in the years to come can hardly ignore the advent of the common market, particularly since the recent failure of the negotiations for a free trade area.

The significance of this failure from a power generation point of view is, to say the least, obscure and, in view of the complexity of the negotiations and of the original concept of the common market, it may be useful to discuss very briefly what this apparently nebulous term implies. The six common market countries originally announced their intention of creating an economic union at Messina in June 1955. Britain did not take part in the preliminary discussions but she subsequently proposed a plan to associate the remaining O.E.E.C. countries with the six in a free trade area. After much political activity, a British Government White Paper was published in February 1957, and this constituted, amongst other things, a statement of what Britain would have regarded as the ideal outcome of the negotiations; in other words, an arrangement which would have excluded trade in agricultural products, brought free trade in manufactured goods, and which would have reduced the supranational political element to a minimum. As in all cases of multi-partite negotiation, the points of view of the six and Britain were modified as the discussions progressed and a general compromise agreement for a free trade area would probably have been reached but for strong opposition from some members of the six.

All those who have planned the European common market have been influenced in various ways and to varying degrees by the fact that their respective countries have been twice subjected to the rigours of war in one lifetime. The people in the six countries who had lived through this experience were willing and, indeed, anxious to follow the politicians who proclaimed that only in a federation of states would they find security. In view of this, the British proposal for a free trade area to be associated with the European common market never had any hope of success. There are, however, other solutions to the present impasse apart from the extreme of economic warfare between two teams of six, made up of the common market countries on one hand, and the Scandinavians, Austria, Switzerland and Britain on the other.

Any definite economic split could not, over a long term, leave existing political alignments and commitments unaffected. The present structure of European trade is the outcome of natural forces, of the comparative advantages enjoyed by producers of various goods in various countries, and no commercial conflict can be anything but detrimental to everyone concerned.

All members of the common market community have interconnected power transmission systems and, as far as Britain is concerned, the economic potentialities of power exchange have been emphasised by the advanced project for a 160 MW cross-channel link which will probably come into operation during 1960. It is reasonable to suppose that if this international development is a success, it will be followed by other cables until the stage is reached where local problems of peak-load demand in France and Britain can be satisfied more cheaply by exchange than by building new plant. If this is so, then it would be logical for the barter of energy to increase *ad infinitum* whenever and wherever it is cheaper to import than to build; thus, any economic conflict between two blocks of nations might be a drag on this happy development of free exchange.

Hydro-electric resources in Europe are widely and

unevenly distributed and although the trend has been to develop as quickly as possible, economic problems have hampered constructional work in many cases. During the transitional period of the next 15 years or so, the common market community will be implementing the decisions made at Messina and if the original aim is to be achieved, power in ever-increasing quantities will be required to accelerate economic expansion. Whether the increase in generating capacity can keep pace with the demand must to a large extent depend on the investment that each country is able to make but, in any case, since water is the most economic means of power generation for base load on a long term, it is probable that the six are entering a period of intense activity in the development of their hydro-electric resources.

It is to be hoped, and perhaps even anticipated, that the remainder of the O.E.E.C. countries and the common market six will find a universally acceptable solution to the problem which divides them. The concept of a federation of nations in Europe is by no means new and it has taken great skill and constancy from those dedicated to the idea to overcome the basic tendencies for national autonomy. An isolationist policy is outdated and Britain cannot disregard the fact that comparatively insignificant stretches of water such as the Channel now constitute a less formidable barrier than did the mediaeval castle moat to our ancestors. If full integration of economic policies is to be achieved despite Empire Preference and individual national interests, then a free trade in power will be a basic essential; the Utopian condition of nuclear power from Britain making its contribution to European economy, and hydro-electric energy from our Continental brethren satisfying the balance of our domestic peak-load requirements, may thus be achieved on a scale undreamed of today.

World Bank Loan for Japan's Miboro Project

JAPAN is borrowing the equivalent of $40 million in a combined operation consisting of a public offering of $30 million of bonds on the New York investment market and a $10 million loan from the World Bank. The purpose is to provide part of the funds needed by the Electric Power Development Co. Ltd. (EPDC) for the Miboro hydro-electric power project, referred to in an Editorial Note in our October 1958 issue. The Government of Japan will add the net proceeds of the bond issues to its foreign exchange reserves and will lend the yen equivalent to the EPDC, while the Japan Development Bank will re-lend the proceeds of the World Bank loan to the company. The Electric Power Development Co. Ltd., almost wholly government-owned, was established in 1952 and assigned a number of hydro-electric sites to develop as its initial programme. Several of the projects in the programme have already been completed and are in operation, with a total capacity of 748,100 kW. EPDC sells its power wholesale to private electric utility companies.

The Miboro project, for which this financing was obtained, is located on the Sho river, near the west coast of Honshu island. It consists mainly of a very large rockfill dam capable of impounding 330 million cu. m. of useful storage, and an underground power house with a capacity of 215 MW. The average annual generation will be 544 million kWh. The control of river flow afforded by the new dam will enable the Kansai Electric Power Company to generate about 220 million kWh more power a year in downstream plants. The entire output of the Miboro plant will be bought by the Kansai Company.

Construction of the Miboro project was begun in June 1957 and is scheduled for completion by December 1961 at a total estimated cost of 37 billion yen (U.S.$103 million).

West Pakistan Power Take-over

THE West Pakistan Water and Power Development Authority has taken over from the Provincial Governments the entire West Pakistan Electricity Department, excepting the Karachi Electric Supply Corporation. The Water and Power Development Authority was created in April, 1958 to co-ordinate the development and utilisation of the water and power resources of West Pakistan on a unified and multi-purpose basis, previously the responsibility of Provincial Governments. From December it has been under the Chairmanship of Mr. Ghulam Faruque, previously Chairman of the Pakistan Industrial Development Corporation.

Mr. Faruque recently signed in Washington loan agreements with the U.S. Development Loan Fund amounting to nearly $30 million. The reclamation of 1·4 million acres of land affected by salinity and waterlogging, and the construction of a 750 mile high voltage grid to link the Warsak and Multan power stations are the objectives of the two projects for which the loans are to be advanced.

Amongst its other responsibilities the Authority has taken over the Mangla dam, the Gujranwala hydro-electric development, and the Hyderabad thermal schemes, and will be responsible for the high-voltage grid system and the Sui gas power station at Multan inaugurated by the Pakistan Industrial Development Corporation.

The Authority has appointed R. E. B. Willcox and Co., 35/7, Great St. Helens, London E.C.3 as its Agents for Europe.

Turbines for Rusfors

THE Swedish State Power Board have placed an order with Karlstads Mekinska Werkstad (KMW) for a Kaplan turbine, for an output of 55,000 h.p. at 11·7 m. head and a speed of 71·4 r.p.m., for their new power plant at Rusfors on the Ume River in northern Sweden. Power production on this river has only been developed during the past few years, but up to now there are five stations, apart from Rusfors, with KMW turbines. These are Pengfors with three Kaplans (65,000 h.p.), Harrsele with three Francis (265,000 h.p.), Bålforsen with two Kaplans (102,000 h.p.) and Umluspen also with two Kaplan turbines (110,000 h.p.). Total output of the five KMW stations is 597,000 h.p.

The runner of the Rusfors turbine will be the largest ever manufactured in Scandinavia and will have a diameter of 8,100 mm. The design of this unit is based on the turbines for Järkvissle, a Swedish plant on the Indal River, the first of which has just been delivered. Each of the Järkvissle units will pro-

duce 59,500 h.p. at a head of 13·6 m. and a speed of 75 r.p.m. and are scheduled to go into service during the autumn of 1959.

The Kaplan turbine for Rusfors is to be put into operation in December 1962.

Indian Engineers Visit the Kuljian Corporation

THREE engineers from India, Messrs. A. S. Chandrasekharen, M. G. Sadanandam and S. I. Mathrani, recently visited the offices of The Kuljian Corporation, 1200 North Broad Street, Philadelphia, to get a bird's eye-view of advanced U.S. engineering practices.

The visit was arranged by the International Cooperation Administration in the course of a training mission under the U.S. foreign aid programme. The visiting engineers are all employed by Central Water and Power Development Commission of India. They have been in the United States for six months and have included T.V.A. and Bureau of Reclamation projects in their tour.

As part of India's First Five-Year Plan The Kuljian Corporation has completed the engineering, construction and initial operation of the 180,000 kW Bokaro thermal power station, which was a vital part of an overall project of electrical generation which also includes nine hydro-electric stations with a total generating capacity of 198,950 kW located on various rivers. The fourfold purpose of the hydro project was to control the flood waters during the monsoon season, prevent land erosion, provide water for irrigation, and to provide electrical generation for industrial expansion in one of the richest mineral regions of the country.

During the First Five-Year Plan, additional generating capacity of 1·1 million kW was added to the expanding Indian economy, bringing the total, at the end of the First Five-Year Plan, to 3·4 million kW.

The Second Five-Year Plan (1956–61), which is under implementation, now provides for augmentation of the generating capacity by 3·5 million kW, raising the total installed capacity in India at the end of the Second Five-Year Plan to 6·9 million kW.

HICA Annual Report

ENCOURAGING progress is recorded in the Annual Report for 1958 by the Portuguese organisation Hidro Eléctrica do Cávado which is responsible for the development of the Cávado and its tributaries. A full account of recent construction in this catchment was given in our January and February issues, and, as is only to be expected, the major emphasis of the Report is on the completion of Paradela dam, described in our February issue, and on the benefits this addition to capacity has already conferred on the system. Full storage at Paradela was available by the end of March 1958, and although the reservoir was emptied during the summer to permit inspection of the concrete membrane, the additional capacity, together with heavier rainfall during the year, raised the output of the HICA system in 1958 to 796 million kWh from the previous record total, in 1957, of 553 million kWh. On the basis of the output from Paradela during the relevant periods of 1958 it is calculated that in an average year the system now has a capacity of 920 million kWh as against its previous capacity of 500 million kWh. During the year the HICA system provided 32·2% of the total power produced in Portugal and 32·8% of the total hydro-electric output.

During the year preliminary work was continued on the Alto Rabagão development. Levelling operations were completed and the Alto-Cávado/Alto-Rabagão road opened, construction equipment and temporary buildings were transferred from Paradela, living accommodation for workpeople and permanent houses for senior staff were built, and a start made on the work for the diversion of the Rabagão.

Pisões dam, which will form a major feature of the development, will be the largest concrete dam in Portugal; it will contain about one million cubic metres of concrete and will have a developed crest length of about 2 km. It will be of the double-curvature arch type, and has been designed with the aid of what is believed to be the most powerful electronic computer in Europe. A trial-load calculation hitherto requiring several months can now be completed in three hours, and this saving of time has made it possible to carry out a sufficient number of calculations to determine the most economical shape and dimensions for the dam.

Swedish State Power Board Jubilee

WITHOUT much official ceremony the Swedish State Power Board recently celebrated its fiftieth anniversary. However, the really important events of the jubilee year will come in the summer and autumn, when five large power plants will be put into operation, two of which will be the biggest of their type ever completed in Sweden and even holding some world records as to special design and output.

Sweden's largest hydro-electric plant, Stornorrfors, to which we have referred on numerous occasions, and which will have a capacity of 375 MW—25 MW more than the Harsprånget station above the Arctic Circle—will be officially inaugurated on September 1. The first two turbines have been running for some time, the third is under installation, and space is available for a fourth. These generating sets, which comprise NOHAB turbines and ASEA generators, are rated at 125 MW and are amongst the largest in the world. The tailrace tunnel, of 400 sq. m. in cross section, is by far the world's largest water tunnel.

Two more water-power plants, Järkvissle and Långbjörn, having a capacity of 87 MW and 80 MW respectively, will start operating in the summer and autumn. These plants have used different methods of dam construction. The former is a rockfill dam on a drainage bed, whereas the latter has been built according to the Concretor-Prometo slide-casting system. This method is also to be used for the Messaure dam above the Arctic Circle, which has a height of 100 m. (330 ft.) and impounds a reservoir containing 13 million cu. yards of water. One of the great advantages claimed for the new Swedish dam-building system is that it cuts building time by 80%.

The fourth station is Stenungsund, on the Swedish west coast, which will be the world's largest underground steam power station. Its initial capacity is 300 MW but two more rock halls are being excavated to accommodate a total capacity of 700 MW. The commissioning of the first stage of the installation is

to take place on October 1 of this present year.

The fifth power station is the remote-controlled gas-turbine plant at Västervik, on the Swedish east coast. This plant will have a nominal rating of 40 MW and is to be taken into use commercially on October 1.

More Norwegian Power Export to Sweden

THE Norwegian Government has put before the Storting (Parliament) plans for a 200 million kWh per year hydro-electric power station at Hegsetfoss on the River Nea in the Sör-Tröndelag county. The construction will be financed through a Swedish loan of 50 million kroner (£2·5 million), which is to be paid back by delivery of power to Sweden over 20 years. The station will be built and operated by the City of Trondheim, but the power is to be bought and resold to Sweden by the Government. The price is fixed at 4·5 öre (slightly more than ½d.) per kWh for ordinary power, and 2·75 öre for power delivered during night-time and on Sundays. During summer-time these prices will be reduced to 2·6 öre and 1·25 öre respectively. When the twenty-year export contract has been fulfilled, all power will go to Norwegian consumers. The Storting have previously passed a similar project on the same river.

Scottish Contracts Placed

THE North of Scotland Hydro-Electric Board have placed contracts for the main civil-engineering works of their Loch Glashan scheme on Lochfyneside and for the plant of two stations of their Strathfarrar and Kilmorack scheme in Inverness-shire. The Loch Glashan scheme will produce 17,600,000 kWh, and annually provides for harnessing the waters of Loch Glashan which lies north-east of Lochgilphead in the hills behind Lochgair village. The works consist of a main dam at the outlet of Loch Glashan from which water will be led by tunnel and pipeline to a 6,000 kW power station situated on the shore of Loch Gair, a bay on Loch Fyne. The natural catchment of Loch Glashan is four square miles but the rainfall on a further 20 square miles will be utilised by means of collecting aqueducts. William Tawse Ltd., Aberdeen, have been given the contract to build the dam at Loch and the generating station. Reed & Mallik Ltd. will construct a system of collecting aqueducts and other works to make use of the upper River Add and River Tunns, and James Young (Contractors) Ltd., Glasgow, will construct aqueducts and other works on the headwaters of the River Crarae. The civil engineering consultants for the Loch Glashan scheme are Messrs. Crouch & Hogg, Glasgow, and the electrical and mechanical consultants are Messrs. Strain & Robertson, Glasgow.

The Strathfarrar plant contract is for four 10 MW Kaplan turbo-generators to be installed in the Aigas and Kilmorack power stations. These two power stations, which will each have a capacity of 20 MW, will be situated on the River Beauly. The alternators will be manufactured by Bruce Peebles & Co. Ltd., Edinburgh. The turbines, which will be of Boving design, will be made under sub-contract in the west of Scotland. The electrical and mechanical consultants for the Strathfarrar and Kilmorack scheme are Messrs. Kennedy & Donkin.

Correspondence

Bolted Angle Struts

To the Editor, WATER POWER

Mr. Gregory's article on bolted angle structures in your January issue prompts me to present a thesis of design to cover the buckling of angles loaded on one leg only, which is a condition commonly encountered in transmission-tower frames.

Everyone who has to design braced frames knows that if an angle has only one leg loaded, the buckling load is diminished (unless there can be restraints sufficient to annul any bending moment at the middle of the strut; but this is an exceptional case). If the slenderness ratio (l/r) of such a strut is very high, the maximum stress occurring at the end of the loaded leg will remain below the yield point when the average compressive stress approaches Euler's critical value. The buckling load is progressively less influenced by the eccentricity as the slenderness ratio increases, but for intermediate or low values of the slenderness ratio, plastic strains occur before buckling and exact calculations become extremely difficult. However, it is possible to find a simple solution by reasoning in the elastic region.

Let us assume an angle the length of which is zero; its longitudinal strains will be equally null and there can be no bending moment, which would imply unequal stresses and thus unequal strains. Thus, if a normal load is applied uniformly to one of the legs (Fig. 1), it is this leg only which bears load, and, in the ordinary case of an angle with equal legs, the average possible stress has to be divided by two, i.e. it is equal to one half of the yield point.

In these conditions, the curve which gives the buckling load as a function of the slenderness ratio starts

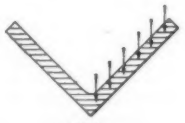


FIG.1

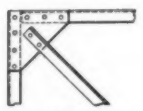


FIG.2

FIG.3

from half the yield point (the slenderness ratio being zero) and meets Euler's curve asymptotically when the slenderness ratio becomes infinite.

The only exceptions concern struts which are bolted to gussets so that these cannot be folded, e.g. in a corner of two other angles (Fig. 2). Then restraining moments occur which annul the effects of load eccentricity. Another example is that of braces directly bolted on the leg of a strong member (Fig. 3). Two ways of buckling are then possible for the brace, either with annulled eccentricity of load (minimum moment of inertia) or with full eccentricity of load (medium moment of inertia).

R. MERCIER.

9, passage Jean Nicot,
Paris, VII.

Book Reviews

The Pump Users' Handbook. By Herbert Addison, O.B.E., M.Sc., M.I.C.E., M.I.Mech.E. Sir Isaac Pitman & Sons Limited, Parker Street, Kingsway, London, W.C. 2. 1959. 122 pp., 55 ff. Price 37s. 6d. net.

This book has been compiled on behalf of the British Pump Manufacturers' Association to give the actual and prospective pump user simple but authoritative guidance on the choice, installation and control of pumps. The Association could have chosen no better author than Mr. Addison, whose wide experience in hydraulics is placed so adequately at disposal by his happy facility for lucid explanation. Mr. Addison has dodged no technical issues in his endeavour to produce a handbook of value to the ordinary pump user, but he has explained such matters as pump performance, specific speed, cavitation, and pressure surges with a simplicity that will bring these mysteries well within the comprehension of the non-specialist engineer. Both rotodynamic and positive-displacement pumps are covered, and the first chapter is devoted to a meticulous survey of the types of pumps available, both in respect of their construction and in respect of the type of application. Useful chapters are also included on the installation and running of pumps and on diagnosing pump troubles.

Kempe's Engineers Year-Book, 1959. Edited by C. E. Prockter, M.I.E.E., M.I.Mech.E., under the direction of B. W. Pendred, M.I.Mech.E., M.I.S.I. Published by Morgan Brothers (Publishers) Limited, 28 Essex Street, Strand, London, W.C. 2. Two volumes, 2,740 pp. Price 82s. 6d. Postage 2s. 6d.

The 79 chapters in the 64th edition of this excellent year book cover practically every branch of engineering. It is an invaluable source of reference and provides the answers to innumerable queries unobtainable in any other single publication.

Three sections in the 1959 edition have been revised and rewritten. Flow Metering and Mechanical Testing; Refrigeration; and Paints and Varnishes. As usual, all the subject matter has been carefully examined and brought up to date. The following are some of the chapters, of interest to our readers, which include additional text: Hydraulic Transmission of Power (details of automatic seated valves, variable stroke pumps, variable capacity/fixed stroke pumps with variable spill, hydraulic couplings); Railway Signalling (details of automation in signalling, application of electronics to C.T.C., and to control of marshalling yards); Belts, Ropes and Clutches (details of clutches); Electrical Engineering (details of electrical performance of rotating electrical plant); Aerodynamics (details of wind tunnels, wind tunnel test methods, helicopters, convertiplanes, V.T.O.L. aircraft, S.T.O.L. aircraft); Fuels (details of heat insulation and thickness of lagging, costs of lagging); Road Vehicles (details of automatic and semi-automatic transmissions, voltage regulator circuits, and permitted gross laden weights); Explosives (details of liquid/oxygen, Cordtex, multi-shot rounds, Cardox, Hydrox); Foundations and Earthwork (details of cast *in situ* concrete piles, and sheet steel piling); Clays and Allied Products (details of lightweight bricks, perforated bricks, highly-porous bricks, heat insulating materials, insulation of furnace walls); Mortars, Cements and Adhesives (details of sulphur cement, iron cement, glycerine-litharge cement, damp-proof courses); Concrete and Reinforced Concrete (details of fire-resistant concrete, expanded shale concrete, reinforcing bars, revised formulae for design of R.C. beams). The chapter entitled Mechanics now includes the fundamental formulae dealing with motion of missiles, motion of satellites, and escape velocity.

Hilfstafeln zur Bearbeitung von Wasserbaulichen und Wasserwirtschaftlichen Entwürfen und Anlagen (Tables for Design of Hydraulic Structures). By Schewior and Press. 7th edition. Published by Verlag Paul Parey, Lindenstrasse 44-47, Berlin, S.W.61, Germany. 1958. 68 pp., 40 ff. DM 51.

These tables first appeared in 1907 when Schewior edited a work intended to aid irrigation engineers. In 1954, Prof. H. Press of the Berlin Technical University produced a completely revised 6th edition, incorporating modern developments and embracing a much wider field, including hydro-electric structures.

This new 7th edition, based on the latest theoretical development in fluid mechanics, is a revised and enlarged version of the 6th edition. It includes diagrams for the calculation of flow in pressure and free-flow pipes and canals of different shapes; backwater curves, drains, weirs of different shapes; nozzles and orifices.

The book is well produced and the tables are of obvious value to any engineer specialising in hydraulic design.

Barrages Mobiles et Prises d'Eau en Rivière (Controlled Weirs and Offtakes). By M. Bouvard. Published by Editions Eyrolles, 61 boulevard Saint-Germain, Paris (5e), France. 244 pp. 128 ff. Price 2,760 francs.

An offtake is designed to divert part of the flow of a river so that the water can be used for irrigation, power production, or industrial and human consumption. The essential problem is, however, not the diversion itself, which is always comparatively simple, but the removal or reduction of foreign matter suspended in the flow.

This book gives a detailed technical progress report on weirs and offtakes, and cites over 200 structures, in France and elsewhere, which have provided valuable experience and have helped to improve designs and constructional techniques. M. Bouvard does not pretend to solve all the problems caused by sedimentation and the transport of solids, but his work will give engineers interested in these natural phenomena an excellent theoretical and practical appreciation of the subject, and an idea of what can still be done to improve the design of equipment intended to counteract their effect.

DAREX Air-Entraining Agent. Evode Limited of Stafford, manufacturers of building chemicals and protective paints, announce that they have now been appointed sole distributors for Darex AEA air entraining agent and WRDA (water reducing agent for concrete)—both products of Dewey & Almy Limited of London. Distribution will be handled by the Building Chemicals Division who have technical representatives throughout the country.

Fig. 1. Chute-des-Passes canyon and entrance to No. 3 access tunnel

Chute-des-Passes Project

About 100 miles north of Isle Maligne, in Quebec, the Aluminum Company of Canada, Limited, is building its Chute-des-Passes project, which will have a capacity of one million horsepower

THE Chute-des-Passes project will utilise the waters of the Peribonka River to develop hydro-electric energy by means of an underground power station and system of tunnels and will deliver that power to the Alcan transmission network at Isle Maligne. One million h.p. of generating capacity will be installed in the station, and will be interconnected with the 2,580,000 h.p. of generating capacity already available in Alcan's Saguenay distributing system. A maximum static head of about 630 ft. will be obtained by utilising the Passe Dangereuse dam and the rapid fall of the river immediately downstream. Water from the Passe Dangereuse reservoir will be discharged into the Peribonka River roughly eight miles downstream of the dam.

Description of Project

The installation at Chute-des-Passes is designed to utilise the total hydraulic capacity of the flow above the Passe Dangereuse dam which was built across the Peribonka River in 1945 to regulate the waterflow to the power stations downstream. Control works and channel improvements to be built will regulate the discharge from Manouan Lake into the Passe Dangereuse reservoir. All the regulated storage above the Passe Dangereuse dam will be effective in increasing the system energy, as it will be utilised through the Chute-des-Passes power house and the various downstream plants.

The principal features of the project include a completely submerged intake in the reservoir, an intake control structure, a concrete-lined 34 ft. inside diameter horseshoe-shaped pressure tunnel nearly 31,000 ft. long, a surge shaft and surge chamber about 2,000 ft. upstream from the underground power house, a draft-tube manifold which regulates the turbine discharge elevation and also acts as a surge chamber for the 48 ft. diameter 9,000 ft. long tailrace which will discharge the water back to the Peribonka River. Power from the generators will be carried by low-tension buses through vertical shafts to a surface substation about 450 ft. directly above the power house. A transmission line about 100 miles long will carry the power to Isle Maligne, initially at a tension of 160,000 V but eventually at 380,000 V.

The intake is being built in the dry at the shore of the lake formed by the Passe Dangereuse dam and about 600 ft. upstream of the dam. This intake will have two 15 ft. by 38 ft. high gate openings with bottom sills about 130 ft. below the high water level. Slots for an emergency bulkhead will be constructed in front of the operating gates, and in front of the

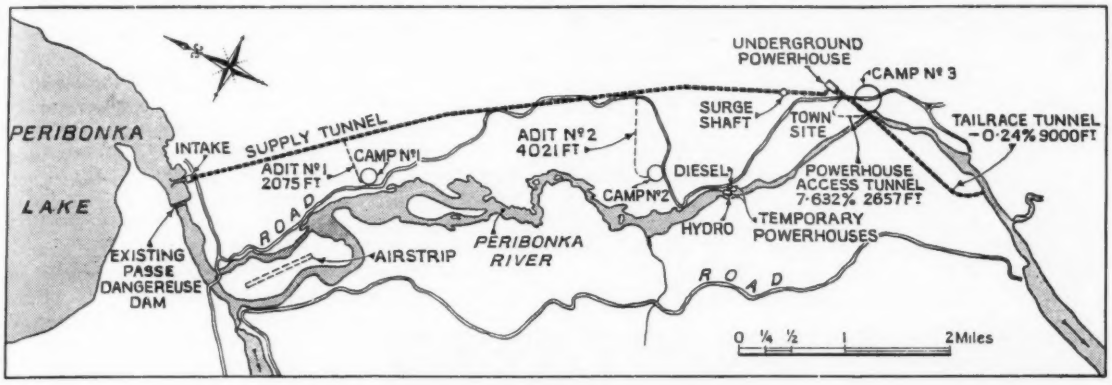


Fig. 2. Map of the Chute-des-Passes development

bulkhead slots there will be trash racks with ample space for cleaning operations. Water will be conducted to the intake structure by a 600 ft. long tunnel that will open up into the reservoir. At the upper end of this intake tunnel a 50 ft. high plug will be blasted out at the appropriate time. The blasting of this large rock plug is a very interesting feature of the project. A sump will be excavated beneath the plug to receive the 15,000 cu. yards of rock contained in it. Just behind the gates there is a vent shaft large enough to give access for equipment to be taken into the tunnel for maintenance and service requirements.

The supply tunnel will be 30,854 ft. long from the intake gates to the branch of the five penstocks leading to the turbine sets. This tunnel will be fully lined with concrete to a minimum thickness of one foot. The average thickness expected is about two feet. It is horseshoe shaped and the inside dimensions will be 34 ft. in height and in width.

About 2,000 ft. upstream of the turbines there will be a surge chamber connected to the tunnel through a 35 ft. diameter shaft. The surge chamber itself will be 130 ft. in diameter and about 130 ft. high. To accommodate temporarily the very substantial quantities of water that might be expected to be rejected under a sudden rejection of load, a basin will be excavated at the side of the surge chamber to retain this surge water and feed it back into the hydraulic system. The reason for the retention basin in this case is not to save the water, but to avoid the hazard connected with the possibility of two million cu. ft. of water being discharged from the surge chamber in a matter of minutes and pouring down the steep hillside.

Five penstocks branch off from the main tunnel near the power house. These will be steel lined and at the point of branching from the main tunnel will be 14 ft. 6 in. in diameter, reducing to 11 ft. at the point of entry to the power house. Penstock valves will be just inside the power house, and will control the flow from the penstocks to the units immediately downstream. These five valves are identical sphere valves, double seal, hydraulically operated with intake and discharge openings 11 ft. in diameter.

Inside the power house will be five vertical Francis-type turbine-generator units, each rated at 200,000 h.p. The turbines discharge through individual draft tubes to a common manifold excavated in the rock downstream of the power house. Each of the draft-tube discharge openings will have gate slots and there

Fig. 3. Outlet of the tailrace from the Chute-des-Passes underground power house; view taken before blasting the river bank

will be a single gate complete with gate-handling equipment. With this gate it will be possible to isolate any one unit by positioning the gate and closing the penstock valve to allow access to the water passages.

The underground power station is 500 ft. below the surface and is accessible through a 2,600 ft. tunnel. It will be 460 ft. long, 70 ft. high and 70 ft. wide, but the arch will be 120 ft. above the low point in the draft tube and considerably more than 70 ft. above the excavation in the power chamber itself. The arch of the power chamber is heavily concreted and grouted above the concrete. Two 210 ton overhead travelling bridge cranes, each with an auxiliary 25 ton hook, will be installed to handle the heavy equipment. The crane rails and girders will be supported on concrete columns and carried up from the floor of the power-house excavation. These columns are deeply anchored into the power-house walls with wedged dowels, and will help the rock bolts to stabilise the walls.

The draft-tube manifold will collect the discharge from all the turbines and feed it to the long tailrace tunnel. The manifold chamber is 410 ft. long by 62 ft. wide and 102 ft. high and will serve as a surge chamber for the tailrace; to attain this end a vent shaft has been driven up to the surface.

Fig. 4. Downstream face of the existing Passe Dangereuse dam on the Peribonka River

Fig. 5. Retention basin of the surge tank, which has a capacity of 2,000,000 cu. ft.

The tailrace tunnel will carry the water under the Peribonka River for a distance of 9,137 ft. and then discharge it from the opposite bank. This tunnel will be 48 ft. in diameter and will be unlined. A wide concrete sill at the downstream discharge structure will maintain both pressure on the tunnel and ensure that it is kept drowned. To maintain the structural stability of this tunnel, which is unlined, aluminium rock bolts, selected for their resistance to corrosion, are being installed systematically as the driving proceeds.

Permanent access to the power house will be through the access tunnel driven for construction, which starts near the bank of the Peribonka River and descends along a curving route to the power chamber about 120 ft. below the surface and 2,600 ft. inside the mountain. Another means of access will be by a 500 ft. elevator that will connect the service building at the surface near the transmission substation to the power house at the control-room end. As the permanent housing for the personnel will be located near this service building, it is expected that the elevator will be the normal means of access to the power house.

From each of the five turbine-generator units low-tension rigid aluminium buses will carry the power through a vertical shaft to the surface about 500 ft. above and will tie into a bank of three single-phase transformers in the outdoor substation. The high-tension leads from the transformers will deliver power through the substation to the two transmission lines, 100 miles in length, to Isle Maligne where they will tie into the existing Alcan transmission system.

The substation will be arranged so that transformers can be moved from position by a transfer

car to load to a heavy-duty trailer that can carry an assembled transformer to the power house for servicing and repair. Initially, it is planned to operate this transmission line at 160,000 V, but eventually the line will operate at 400,000 V and will be reduced to system voltage (160,000 V) at the Isle Maligne end.

Another interesting feature of this project is that it has been planned to construct a control works at Manouan Lake at the upper end of the Passe Dangereuse reservoir. These control works will regulate the discharge of Lake Manouan into the Passe Dangereuse reservoir thus extending control of the discharge available for the generation of power both at the new Chute-des-Passes station and the various downstream plants. Access roads from the head of navigation of the Passe Dangereuse reservoir have been built and some camp facilities completed, but construction is not active at the present time.

The engineering and design contract for the project was awarded to H. G. Acres & Co. Ltd., of Niagara Falls, and this company collaborated with Alcan in the preparation of the contract for construction. The prime contract for construction was awarded to a group organised under the name of Perini McNamara Quemont, with Perini (Quebec) as the sponsor.

The prime construction contract is unusual enough to warrant remark. It was a unit-price contract with the major units of construction identified in a bid schedule. Some few items that could not be identified or evaluated with reasonable accuracy at the beginning of the project were intentionally left out of the bidding and provisions made for extra work to be negotiated on a unit price basis or carried out on a cost-plus fixed fee in case agreement could not be reached on negotiated prices. Examples of these kinds of items are the tunnel supports, grouting and guniting, which could not be determined until the underground work was opened up. The bid proposals invitations sent to various contractors in the area outlined the number of adits, working areas and other main features of the construction operation. The

Fig. 6. Concreting ramp in the main supply tunnel. Note the aluminium roof bolts

Fig. 7. Part of the main supply tunnel after lining

access road to the project was not included in this contract as it had been started by Alcan many months before the prime contract was negotiated. This was done to ensure that the road would be in service at the time the construction started. A total of 140 miles of access road had to be improved, and in the north a hundred miles of road had to be virtually rebuilt. An item in the prime contract was transportation of all materials from the railhead at Isle Maligne to the project site.

The unusual features of the contract involved an advance payment to the contractor to cover the mobilisation of forces and administrative personnel and provision to prepay costs of camp equipment, construction plant and buildings. These items were bid as lump sums. Alcan agreed to pay these costs as they were incurred; if the contractor spent less than his lump sum bid, the difference would be given him at the time of completion of the work. If he spent more, he had to finance this independently of the contract. The purpose of all these provisions was to reduce the "unknowns" to the bidder and to reduce the requirements of the general contractor to finance, as the contract was awarded in 1956 when money was very hard to obtain.

Access to the underground workings was obtained through three adits which were all developed from along the Peribonka River and driving to the eastward to the underground work centres. The first adit was located 7,500 ft. downstream from the intake and was 2,283 ft. long. Adit No. 2 was nearly at the centre of the supply tunnel 14,200 ft. further downstream and had a length of 4,376 ft. Adit No. 3 entered the power-house area and was 2,600 ft. long. This adit will be kept open for permanent access to the power house. Adit No. 3 is the only one for which a size was specified in the bid invitation as it had to be large enough to carry transformers down to the power house for servicing. As the excavation plans of the contractor were based on hauling with large tractor trailer and dump rock bodies, the adits were made wide enough so that two of these units could pass.

The contractor set up his forces with a superintendent for each adit, each of these officials being responsible for the work underground, for the camp at that adit and for all the related service facilities. The general field headquarters for the contractor, H. G. Acres, and Alcan were all at adit No. 3 near the power house.

After the adits had been driven to the permanent tunnel or power-house location, headings were developed at all possible points. Branch adits were driven from adit No. 3 to provide access directly to the draft-tube manifold, to the tunnel upstream and to the discharge tunnel. The main supply tunnel excavation was attacked at five headings, two from adit 1, two from adit 2 and one from adit 3. The power-house excavation was handled through adit No. 3 as was the tailrace excavation. The general procedure of the contractor was to excavate the top bench at each of the supply tunnel headings, leaving about 12 ft. of the bench to excavate later. This top-heading operation, in contrast to full heading, was in the interest of speeding up the initial driving, holing through to provide better ventilation and permitting a faster start on the concrete lining in the supply tunnel.

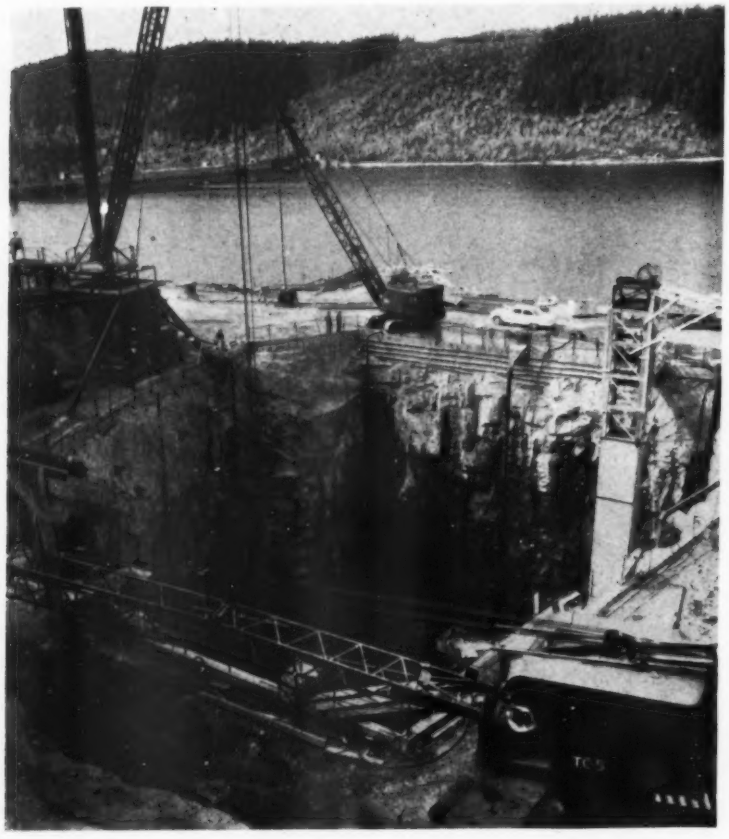


Fig. 8. Excavating the shaft leading to the intake tunnel

Tunnel excavation was handled by heavy-duty drifter drills mounted on jumbos that were shifted by crawler tractors. The drills were powered by compressed air developed at a central compressor plant located at each adit. Twenty-one drills were mounted on each jumbo and as the air capacity provided was not sufficient to support drilling from two headings at one time, the drilling had to be alternated. This meant that the whole cycle of drilling, blasting and mucking each of the two headings from one adit had to be kept one step out of phase. Following the blasting, the muck was loaded on DW-21 tractors hauling PR-21 end dump rock bodies, and these units were loaded with electrically-driven standard crawler shovels. During the drilling cycle, rock bolts, where required, were placed in the arch of the tunnel that had just been blasted.

At the present time the entire supply tunnel upper bench is completed, and the lower bench removal is virtually finished. The lower bench was handled by two methods to try and appraise their relative value, but there is no conclusive evidence that any one has proved to be better than the other. The first method was to excavate the bench by down drilling, where-

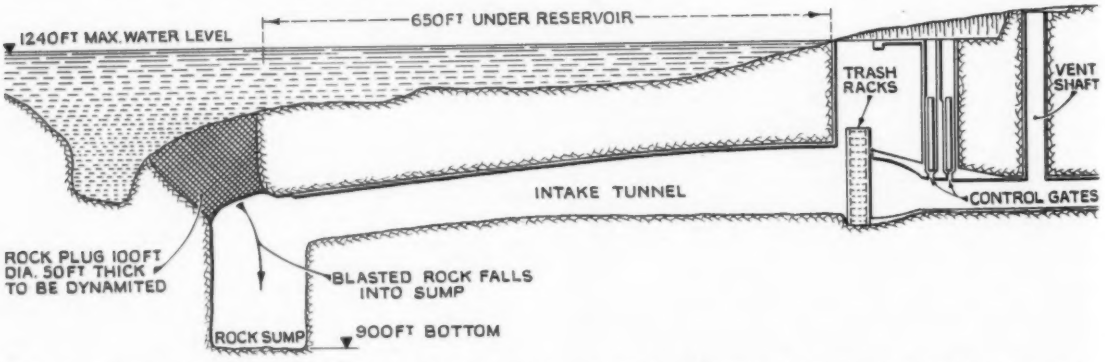


Fig. 9. Section through the intake tunnel, showing provision for blasting the rock plug in the river bed

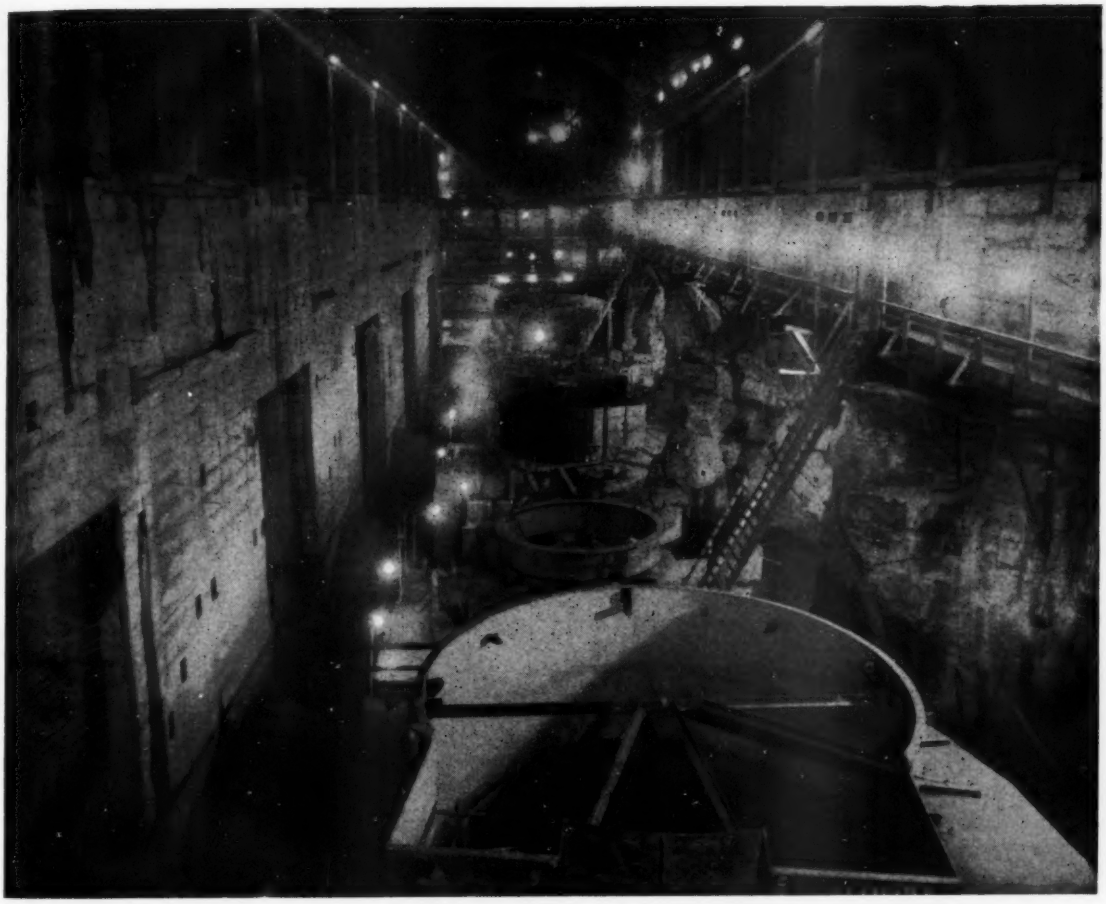


Fig. 10. Chute-des-Passes underground power station under construction

as in the other horizontal drilling from a jumbo was used, in the same manner as the original top heading was excavated. Extremely good progress was maintained by the tunnel driving crews at all headings. The best week of progress was 324 ft. for one heading in November 1957. In addition to the record progress made in linear, the project made, we believe, new records as to the volume of rock excavated from a tunnel heading in a given period. Work operations were carried on two twelve-hour shifts and the project was set up so that incentive pay was paid to the miners for footage gained beyond a basic quota.

In the power house and the draft-tube manifold area the arch section was first excavated, and the material dropped down a steep ramp to the access tunnel. In this area horizonal drilling was applied and loading was accomplished by electric shovels. After the excavation of the arch section, heavy haunches were concreted in the walls to carry the power-house arch, after which the power-house arch concrete was placed behind sections of full arch forms supported from the rock bench at spring line. Subsequently, the main body of the excavation was taken out through another tunnel driven along the line of the power house at the lower level. The excavated material was dropped through vertical shafts tapped at the lower end and fed into the hauling units for removal.

Excavation of the tailrace tunnel was carried on from the power-house adit in much the same manner as the supply tunnel work.

Excavation at the intake structure started from the surface in the bank of the reservoir. When the tunnel excavation from adit No. 1 passed through the intake, a shaft was started, driving upward through the intake excavation. This raise has been completed and is now receiving the bulk excavation from the intake which is being hauled out through adit No. 1. Tunnel driving continued past the intake into the intake tunnel which will connect into the reservoir. This work is now deep under the reservoir and is proceeding very carefully with long holes drilled well ahead to ensure that the rock is not fissured and that the drill holes will not tap into crevices leading to the reservoir. Systematic grouting is injected ahead of the heading. The main intake to the tunnel is about 600 ft. upstream from the intake structure. The plan is to carry this excavation so as to leave a 50 ft. vertical thickness of rock above the intake opening. A sump excavated in the rock below the intake opening will accommodate the debris from the plug when it is finally blasted out.

The exact routine of this operation has not been

fixed in all details but the general procedure is defined. The operation will not be dissimilar from the famous blast of Ripple Rock in British Columbia which was successfully carried out some time ago. To avoid serious shock to the intake structure gates and other facilities a bulkhead has been built just downstream from the intake. This will permit the plug to be blasted and water to be admitted to the upper section of the tunnel with the gates raised. After the blast the gates can be lowered and the bulkhead removed through adit No. 1.

All the shafts on the project have been raised, working from the bottom up, at least to the extent of developing a pilot shaft to carry muck. Except for the intake, all of the raising activities were operated through adit No. 3. The shafts so raised were the surge shaft, the elevator shaft in the power house, the ventilation shaft from the draft-tube manifold and the five bus shafts from the power house.

A central aggregate and concrete plant was located over adit No. 2 and a 450 ft. hole was opened into the access tunnel so that concrete could be dropped into the tunnel without hauling it around the circuitous route on the surface. A complete plant was set up for aggregate classification and crushing. The central mixing plant included four 4 cu. yard mixers. For lining, a set of steel concrete forms, 160 ft. long when assembled, are bolted to curbs, and concrete is pumped into them through two double pumpcrete machines. Concrete is supplied by ready-mixed trucks or by ordinary trucks into a remixer and discharged to the pumpcrete machines. The forms for each set up are bulkheaded at one end and have windows to provide access for vibrating and inspecting the concrete as it is placed.

A feature of the concreting set-up in the tunnel is a rolling ramp that permits trucks to drive up sufficiently high to discharge directly into the Pumpcrete equipment, thus eliminating any possibility of difficulty in transferring the concrete. At the top of this moving ramp there is a turntable that turns the trucks around into the dumping position and directs them down the ramp in the right direction for the return trip. In all this concrete arch work, including that of the power house and draft-tube manifold, great care has been taken to ensure that the space between placed concrete and the rock is completely filled up. Above that zone higher pressure grouting is carried on to ensure a fairly homogeneous structure above the concrete. In addition it is anticipated that a curtain wall just upstream from the power house will be grouted to attempt to seal off any possible leakage from the pressure tunnel into the power house.

Only 1,166 ft. of steel tunnel supports have been used in the supply tunnel and the adits, but the principal protection of arching was effected by rock bolts. These bolts were held by a special wedging device designed by the contractor and were bolted up very tightly against heavy steel or aluminium plate washers. In some areas gunite has been employed to prevent the rock from disintegrating. Rock failures have occurred often enough to focus very careful attention on the problem of support but little damage has been done to date, and the protection adopted appears to have been adequate. At the time of writing nearly 220,000 rock bolts have been placed in the underground workings and all the arches have been exposed except the rock plug in the intake itself.

Construction services to the project have been very carefully planned. Under the prime contract, Alcan

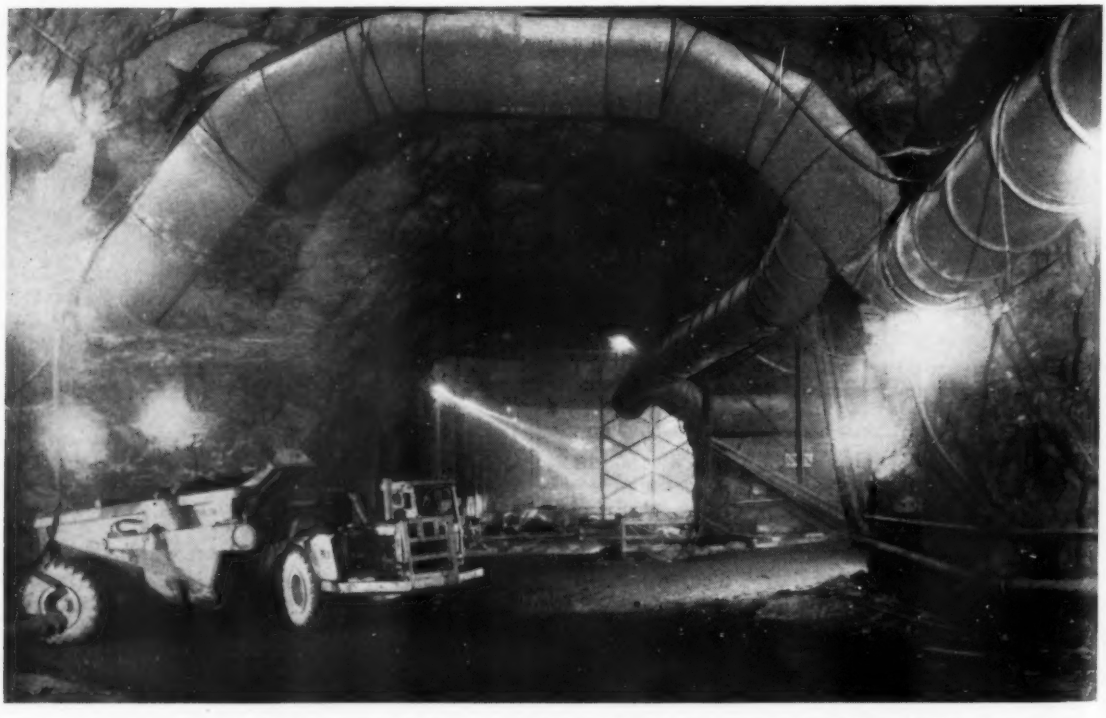


Fig. 11. Power house under construction in the background and access tunnel in the foreground

was to furnish construction power units at the specified use centres, but after the contract was negotiated it was agreed that the prime contractor would carry out the work necessary to provide this power, as a negotiated extra to the contract. Accordingly, 12 diesel-electric generating sets were purchased, each capable of providing 1,000 kW. Three of these units were portable rail-mounted units and were taken to the job quite early to get things started. These three units were set up one at each adit and are still there providing emergency service at the adit in case anything breaks down in the central transmission and distribution system. The other nine units were set up in a central station.

Calculations of the fuel requirements to supply this preliminary power indicated that there would be a substantial advantage in installing a hydro unit, and an investigation indicated that there was a suitable site at hand. Two generating units that had been used on the Bersimis project for the initial constructional work were purchased and installed below a natural fall in the Peribonka River. The location for the central diesel-electric plant was selected to be near the hydro site so that both could feed into a common substation for electric distribution to all points of the project. This temporary hydro plant has proved its value and is now supplying virtually all of the energy to the project, although the diesel sets are being used at times for peaking. The hydro plant can produce 10,000 h.p. dependably, the river flow being easily sufficient to support this output.

Central compressor and blower plants were provided at each of the adits to serve the work in that area. At the peak of the excavation operation, the connected load of the compressors amounted to 3,600 kW and the connected load of ventilating fans was over 4,000 kW. In addition, each adit had one diesel-driven compressor for emergency service in case of difficulty, and this unit was also used to carry peak loads.

Water for the adit camps was derived from various sources but most of it was taken from the Peribonka River. Camps for an expected peak of 2,700 employees were built mostly of prefabricated panel-type construction, most of them being two-storey buildings. As the project was located far from established centres of population, a complete hospital was provided at adit No. 3. Recreational facilities have also been built because of the distance from established centres of population. The first unit of the permanent school was built quite early, the children being transported from the sites of adits 1 and 2 by buses to the school, which is situated near adit No. 3.

Work on the project started in the early fall of 1956 and it is expected that the first power unit will be in operation late in 1959. Excavation of the access tunnels started in October 1956 and by May 23, 1957, was in progress from all adits.

Permanent equipment for the project was purchased by the Aluminum Company and is being delivered by the suppliers to the railhead at Isle Maligne. Installation of the penstocks in the ground started in June 1958, and the power-house cranes were put into service at the same time.

Embedded parts for turbines have been partly delivered and some are installed and embedded. All of the transportation to the job site is being handled by the general contractor through a sub-contract, and this includes both the construction materials supplied directly by the contractor and the permanent materials and equipment supplied by Alcan. For the very heavy lifts different provisions were made for payment for hauling than for ordinary bulk materials. Cement purchased by Alcan and delivered to Isle Maligne is being hauled in tank trucks to the project, and some of these trucks have made two trips a day over the 140-mile access road. All equipment purchased has been constructed under a specification that limits the weight of any single piece to avoid any overload on the bridges of the access route.

The major structure on the access road was the bridge across the Peribonka River near the job site. This bridge was built of heavy steel beams carried on rock-filled timber cribs during the autumn of 1956 to get a heavy-duty bridge available. In 1957 the rock in these cribs was grouted through pipes installed when the initial cribs were placed and the bridge is now on concrete piers anchored into the rock at the river bottom. The road was started in early 1956 and was essentially complete by November 1956, although it was in service long before final completion. In addition to the access road built by Alcan, a landing strip was built at Chute-des-Passes to permit airplane access to the project.

Fig. 12. Excavation work in progress in the main supply tunnel

While nothing startlingly new has been done on this project in the way of construction-plant methods, equipment or procedures, it is an extremely good example of a well-planned, well-organised and well-equipped operation. Probably the most unusual use of equipment is the selection of the trailer rock bodies to haul the tunnel debris and the loading of this rock by power

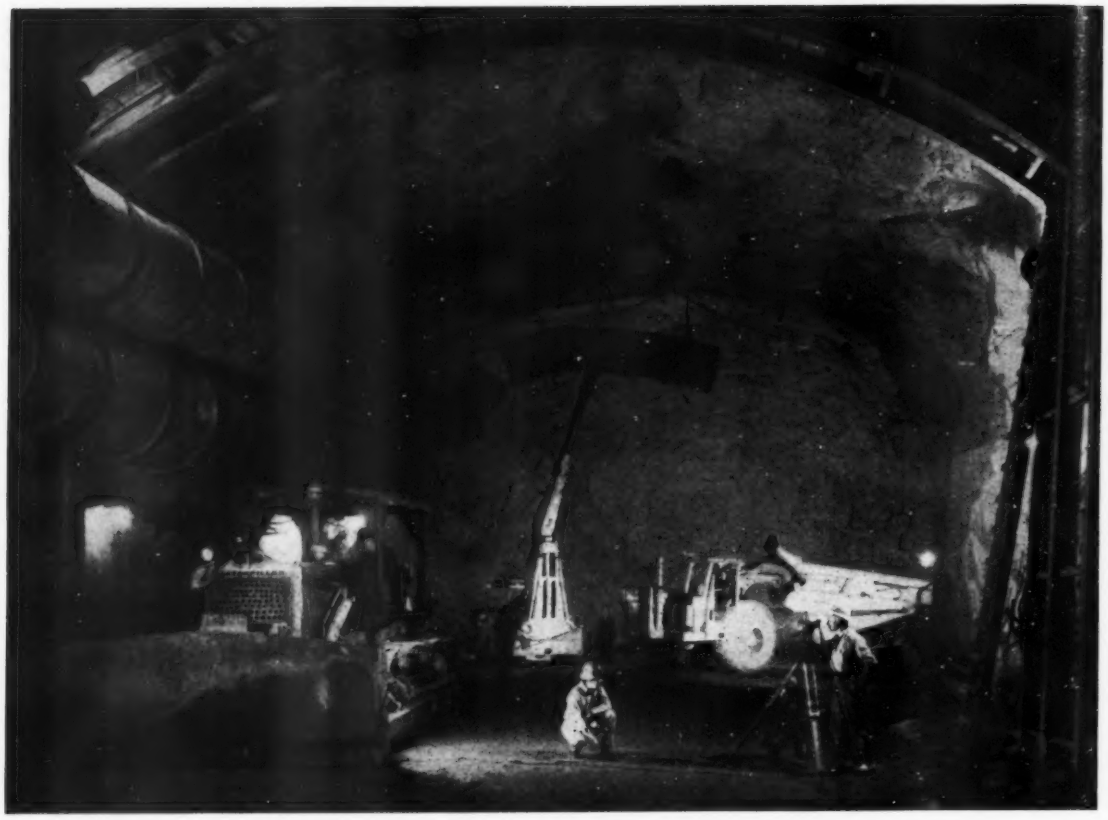


Fig. 13. Early construction work in the underground power house

shovels in the tunnel. This selection of equipment has made it possible to establish the enviable records that have been established.

The general contract for the project, not including the Manouan diversion operation, was awarded to a joint venture of Perini Quebec, Inc., MacNamara (Quebec) Ltd., and Quemont Construction, Inc. The contract for the design and for field engineering on the project was awarded to H. G. Acres & Co. Ltd., who are doing the design work at their headquarters at Niagara Falls, Ontario. The Aluminum Company of Canada, Limited, set up an administrative group to co-ordinate the project and to handle the various responsibilities it has retained for itself. This administrative group does its co-ordinating work in Montreal, working through the various service departments of the Aluminum Company.

This article first appeared in *Roads and Engineering* and was written by Mr. F. T. Matthias, Director of Engineering and Construction, Alcan.

Glenfield to Build New Laboratory

Glenfield & Kennedy Limited have decided to build an entirely new hydraulic laboratory at their Kilmarnock works, and brief details are given in the December 1958 issue of their house journal *Glenfield Gazette*. The main building will be 128 ft. long, 42 ft. wide and 38 ft. high to the eaves, and along one side will be an annexe 51 ft. long, 20 ft. wide and 22 ft. high. At one end of the main block will be a three-storeyed tower 53 ft. high by 55 ft. by 52 ft. containing a pump room on the ground floor, a gallery for the erection of semi-permanent models on the second floor, and a constant-head water tank and an aerodynamics section on the third floor. On the floor of the main building will be the main storage tank surrounded by metering gear, calibration tanks and water-treatment plant, and above it the main floor.

Water will be available at rates from a small flow at 450 ft. head up to 1 cusec at 400 ft. head or from a small flow at 65 ft. head up to 20 cusecs at 35 ft. head, delivery being by gravity, pumping, or a combination of the two. For pumped supplies there will be four pumping sets, which can be interconnected if desired to produce a wide range of effects. They will comprise two 10 cusec single-stage units for direct delivery up to 65 ft. head or to the constant-head tank for a head of 35 ft., a 2½ cusec unit for heads up to 38 ft., and a 1 cusec multistage unit for heads up to 450 ft. either directly or through a steadying air vessel. Flow measurement will be catered for by a battery of venturi meters, a 200 cu. ft. fixed graduated tank, smaller portable tanks and a weighing machine with tanks. Orifice meters will also be available for special duties.

Leakage in Butterfly Valves

This article discusses the watertightness of butterfly valves and suggests a criterion for their acceptability

By S. N. VINZE, B.E.(Elec.)(Bom.), M.S.(Calif., U.S.A.), Mem.A.I.E.E.(U.S.A.), A.M.I.E.(Ind.), Deputy Director of C. W. & P. C. (P.W.)

BUTTERFLY valves are widely used in hydro-electric installations with relatively long penstocks. When installed in the power station immediately upstream of the generating units they may serve a variety of purposes. Where a common penstock supplies more than one generating set, a butterfly valve is necessary in each branch of the penstock in order that any of the units supplied by the common penstock can be shut down and repaired or overhauled while the other units continue working. Further, a valve adjacent to the turbine serves as a second line of defence in case of failure of guide vanes to close completely. (This may be caused, for instance, by the failure of the bolts or shearing pins on one or more guide vanes.) With the introduction of this valve, it is unnecessary to drain the entire length of the water conductor system to gain access to the turbine for maintenance or repairs. Apart from reducing the time of outage of the generating units, this arrangement is also desirable for increasing the life of the penstocks, because a full penstock undergoes very small temperature changes due to the diurnal temperature cycle. Elimination of alternate dry and wet conditions also helps to preserve wood flumes and wood-stave penstocks. Although a number of different types of valves are available, the butterfly valve is widely used because of its cheapness as well as because of its special characteristics. These include low head losses when in the fully opened position, their ability to close easily under dynamic conditions, and their relatively small weight and space requirements, etc.

One of the main factors determining the acceptability of a butterfly valve is its watertightness. Complete watertightness on closure can be achieved if seals of rubber or other resilient material are used. On the larger sizes, the rubber seal consists of a hose which is inflated by pressure water. In practice, however, the resilient seals are prone to be worn out rapidly, or at least materially damaged, by the flow of water and by suspended silt and other material carried by the water. The effectiveness of the resilient seals is therefore reduced after a time and the valve shows an increasing amount of leakage. This means that the water conductor system has to be shut down and drained in order to renew the seals. Such outages are obviously highly undesirable in hydro-electric installations, and metal-to-metal seals having relatively much longer life are therefore preferred.

The sealing with metal-to-metal contact may be in

TABLE I.—EXPERIENCE DATA ON BUTTERFLY VALVE LEAKAGE

Project	Valve diameter d		Head h		Leakage Q		$\sqrt{h}$	$\frac{Q}{\sqrt{g\,h}}$
	mm.	in.	m.	ft.	lit./sec.	g.p.m.	$\sqrt{m.}$	lit./m.
Lauro Dam, Cachuma Project, U.S.B.R., U.S.A.	914	36	28·04	92	0·375	5	5·3	0·0228
Hirakud Dam Project, India	1016	40	35·66	117	0·1515	2	6·0	0·00805
Eklutna, U.S.B.R., U.S.A.	1676	66	246·9	810	1·895	25	15·8	0·0384
Granby Pump Plant, U.S.B.R., U.S.A. ...	1930	76	105·15	345	0·758	10	10·25	0·0242
Granby Pump Plant, U.S.B.R., U.S.A. ...	2235	88	105·15	345	1·138	15	10·25	0·0356
Anderson Ranch Power Plant, U.S.B.R., U.S.A.	2540	100	176·78	580	1·515	20	13·30	0·0366
Boulder Power Plant, U.S.B.R., U.S.A. ...	3048	120	192	630	3·78	50	13·88	0·0870
Ocoee No. 3, T.V.A., U.S.A.'...	3658	144	42·06	138	1·515	20	6·50	0·0745
Apalachia, T.V.A., U.S.A.	3658	144	67·36	222	2·280	30	8·20	0·0890
Nevada Wing, Boulder Power Plant, U.S.B.R.	4267	168	192	630	2·650	35	13·88	0·0610
Boulder Power Plant, U.S.B.R., U.S.A. ...	4267	168	192	630	3·780	50	13·88	0·087
Palisades, U.S.B.R., U.S.A.	4724	186	74·04	243	2·280	30	8·6	0·083

the form of specially machined seats, with or without special metal inserts. These seats can rarely achieve complete watertightness. The question therefore arises as to (*a*) what would be a rational measure for the degree of watertightness achieved, and (*b*) what degree of watertightness may be considered as satisfactory or acceptable in the acceptance tests of such valves. The latter must, of course, be a compromise between what can be attained and what can be tolerated.

It is sometimes suggested that the leakage expressed as a proportion (percentage) of the normal discharge through the full-open valve may be taken as the criterion. Such a criterion is obviously an over-simplification of the problem as it takes into account neither the head the valve has to withstand nor the physical dimensions of the valve. Further, the normal discharge is dependent mainly on the velocity of flow adopted for the penstock design and is not directly related to the valve design. This would lead to inconsistent specification; for example, the higher the penstock velocity adopted, the smaller will be the valve size, but the rated discharge being unchanged, the permissible leakage will remain the same for different sizes of valves.

Another suggestion has been to express the leakage as a fraction of the free discharge through the valve. This also is not entirely satisfactory, though it takes the size of the valve as well as the head into account, because the leakage would not vary as the square of the valve diameter, but the free discharge would. This calls for a sliding rate of permissible leakage discharge for different valve sizes.

When a butterfly valve is shut, the leakage through it will depend upon the static head at the valve as well as the dimensions of the leakage passages. The leakage passages will be disposed along the periphery of the valve, especially at the trunnions. The leakage discharge would be proportional to the spouting velocity of the water and hence to the square root of the head h. The area of the cross-section afforded for leakage flow will depend primarily on the diameter of the valve. The width of the passages, though substantially constant (depending on accuracy of machining) will vary to some extent with the diameter d of the valve. Thus the leakage discharge Q through the valve should be proportional to: $d^n \sqrt{g\,h}$. The index n for d can be determined only from experience.

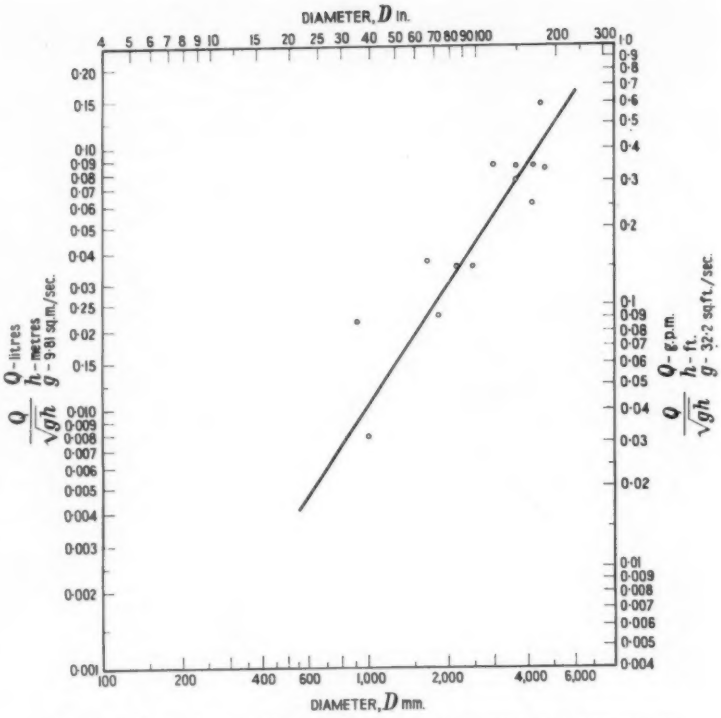


Fig. 1. Experience data from Table I plotted logarithmically

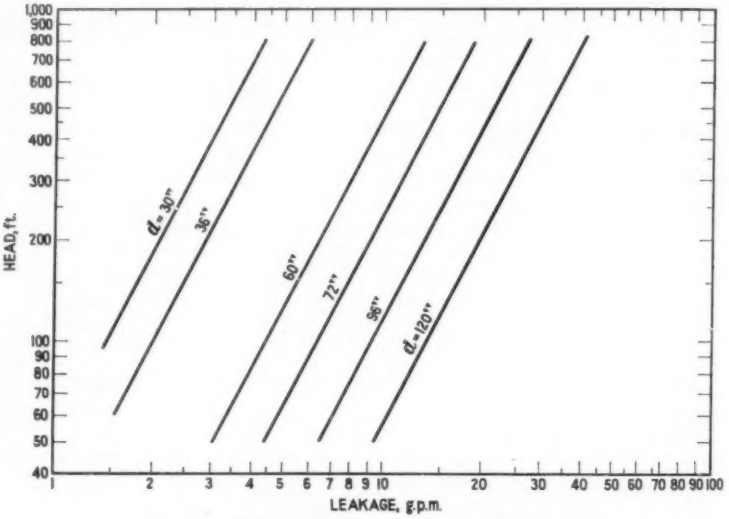


Fig. 2. Allowable leakage at different heads

If, therefore, experience data are plotted on log-log paper, with the diameter d as abscissa and $Q/\sqrt{g\,h}$ as the ordinate, then a straight line should result, the slope of which will give the value of the index n of the diameter. It is desirable to retain the factor g in this equation so that conversion from one set of units to another is facilitated.

Experience data of butterfly valves of some important hydro-electric plants, are given in Table I. The leakage discharge tabulated therein is a leakage per-

mitted or actually found during the acceptance tests, i.e. when the valves were new. These data have been plotted in Fig. 1. In this it will be seen that the experience data lend support to the relationship suggested above and give substantially a straight line on the logarithmic co-ordinates.

The value of n works out to approximately 1·6, thus indicating that the leakage does not increase in direct proportion to d. As the diameter of the valve (and hence the perimeter) increases, the cross-section of the leakage passages would appear to increase somewhat more slowly. This indicates that the clearances do increase with the size of the valve but not in proportion to the diameter.

It is recommended that the graph in Fig. 1 be used to fix the limit of permissible leakage on the acceptance test. In order to facilitate the practical use of the graph, co-ordinates in both the British and metric systems are given. It is considered that this graph may be taken to be applicable for diameters from 500 to 5,500 mm. This covers the range of valves that are most likely to be encountered in modern hydro-electric installations. It may be mentioned that one of the considerations in drawing this limit curve was that the leakage should not be so large as to reduce the usefulness of the valve in permitting maintenance work on the turbine.

Fig. 2, derived from this limit curve, shows the allowable leakage for some common valve sizes for different heads. It is felt that these amounts of leakage can readily be drained to the draft tube by keeping the spiral-casing drain valve open, and therefore would not interefere with the maintenance or repair work in the turbine.

Conclusion

A rational practical limit for leakage through closed butterfly valves during acceptance tests has been proposed, on the basis of available experience data. The proposed limit is that the discharge Q in litres per second should not exceed: $1{\cdot}6 \times 10^{-7}\, d^{1{\cdot}6} \sqrt{g\,h}$ where the head h is in metres and the diameter d of the valve in millimetres.

If Q is expressed in imperial gallons per minute (g.p.m.), the limit is: $Q = 1{\cdot}13 \times 10^{-4}\, d^{1{\cdot}6} \sqrt{g\,h}$, where d is in inches and h is in feet.

Acknowledgment

The author is grateful to Mr. K. L. Vij, director, and Mr. B. T. A. Sagar, for valuable suggestions in the preparation of this article, and to the Central Water and Power Commission for the permission to publish it.

British Electrical Industry's Record Year

According to the British Electrical and Allied Manufacturers' Association, 1958 has been a record year for the British electrical and allied manufacturing industry. For the third year in succession direct exports of the industry have exceeded £270 million. This compares with the 1938 figure of £25 million when Britain was the world's largest exporter of electrical goods. The industry's exports for the five years 1954-1958 totalled £1,300 million, and the industry has exported over £2,500 million of electrical products since the end of the war. Exports of heavy electrical machinery in 1958, including plant for hydro-electric schemes, totalled the record figure of £81 million. Since 1950 the annual production of heavy electrical generating plant in the United Kingdom has increased over 60% and the annual production capacity of the industry now exceeds 3,000 MW.

The largest steam turbo-alternator in the world is being built in Britain for Thorpe Marsh power station near Doncaster, and will have a capacity of 550 MW. The next largest steam turbo-alternator in the world will be the 500 MW set ordered in February, 1959, for the Tennessee Valley Authority from a British manufacturer.

Remarkable progress occurred during 1958 in the development and use of computers and electronic control. Europe's first Electronic Computer Conference and Exhibition was held at Olympia in November, and the papers read revealed great strides in this new branch of engineering. Among export activities in this field can be instanced the export in July of Britain's largest electronic computer, valued at £300,000, to South Africa, and the British-designed electronic control system for steam generating plant installed at Calgary, Canada, which is the world's first of its kind.

The success of the industry stems from its concern with education and research, on which it spends about £35 million each year.

The year saw great progress in the construction of the four nuclear power stations which are being built for the Central Electricity Generating Board and the South of Scotland Generating Board. Berkeley and Bradwell are expected to be commissioned in 1960, and excellent progress is also being made on Hinkley Point and Hunterston. Work was also commenced during the year on the 200 MW nuclear station at Latina, near Rome; and negotiations have been finalised for an order to Britain for building a 150 MW nuclear power station in Japan. At home, Calder Hall entered its third year of uninterrupted production, and by the end of 1958 had supplied 1,000 million kWh to the National Grid. Its 140 MW sister nuclear power station at Chapel Cross, near Annan in Scotland, neared completion. Chapel Cross nuclear power station actually commenced supplying electricity to the National Grid in February, 1959.

Films and Models of Civil Engineering. A number of civil engineering contracting firms have films and models which are available for loan to schools and universities, educational authorities, clubs, societies, professional associations and others interested in civil engineering projects at home and abroad. An up-to-date list of these films and models has just been prepared and copies may be obtained free of charge from the Federation of Civil Engineering Contractors, Romney House, Tufton Street, Westminster, S.W.1. Four films on hydro-electric schemes are included—Lochalsh, Moriston, Owen Falls (Uganda) and Roxburgh.

Model Investigations on Bolted Angle Structures

Tests carried out at the University of Tasmania on a model of a lattice girder for an electricity transmission tower show the influence of the bolted connections on the load-carrying capacity of the members

By M. GREGORY, B.E., A.M.I.C.E., A.M.I.E.(Aust.)

A CONSIDERABLE number of engineering structures are made of bolted angle members. Tests show that existing design methods are over-conservative, even in cases where the standard codes are not used, and member sizes have been carefully pruned.

The Transmission-Tower Problem

In the case of an electricity transmission tower, we have a structure which can be tested full scale. Because of the number of structures involved, new designs for transmission towers are often tested. In design, an estimate is made of the wind loading on the tower and on the conductors, and also the effect of cable breakage. A tower can be erected, subjected to some of the design-load combinations, and tested to destruction under one of the loadings. By this means, at least, one can check the design; but the only check on the assumed loadings is that of the service of the structure.

Because a full-size test can be carried out, the transmission tower is probably one of the most economical structures designed. Most designers work on permissible axial stresses much higher than the standard civil-engineering codes allow. However, it is felt that there is still room for valuable economy.

Saving in Cost

Saving in cost by improvement of design can come by two different procedures. The first is one of cautious pruning of design. Realising the ample strength of their structures, designers look for avenues where too-conservative assumptions can be pruned, reasonably and safely. One example is the reduction of the assumed wind loading on the conductor by taking account of gusts. The loading can be considerably reduced by taking the maximum wind velocity on only part of the cable. Measurements of cable tensions and deflections show that this procedure is safe. Again, in view of the ample strength of the structure as designed (i.e., given the loading) a tower designer may feel justified in using shorter effective

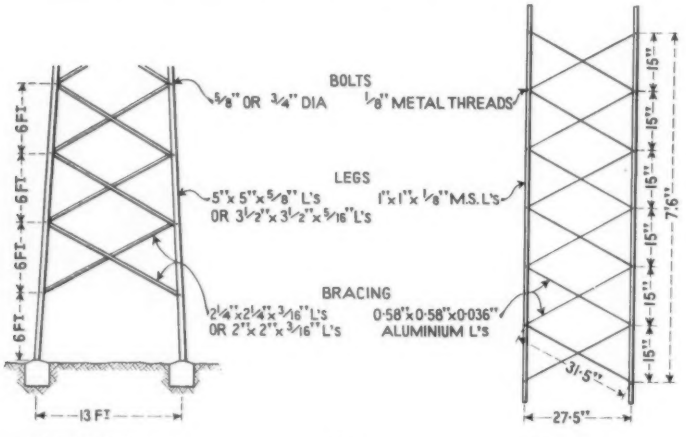
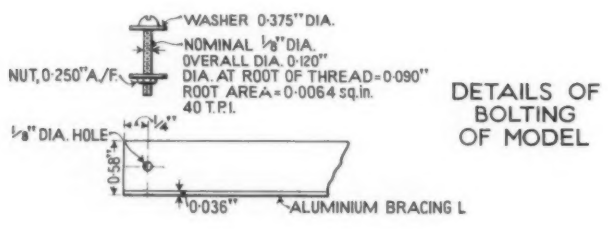


FIG. 1



DETAILS OF BOLTING OF MODEL

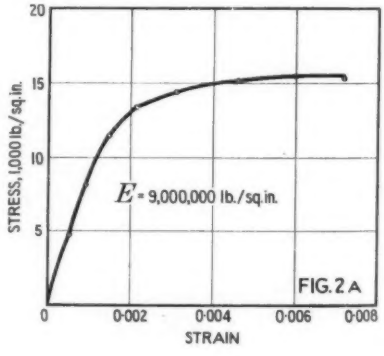


FIG. 2A

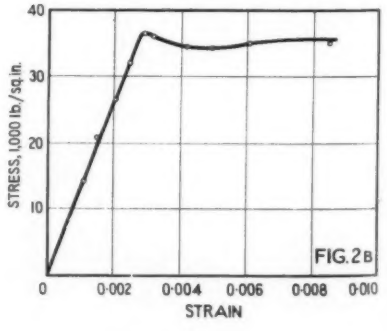


FIG. 2B

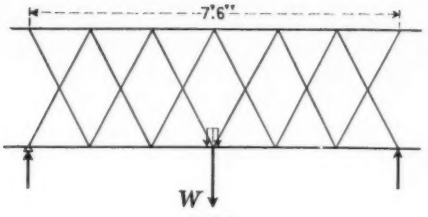


FIG.3

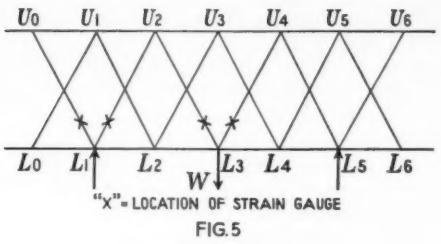


FIG.5

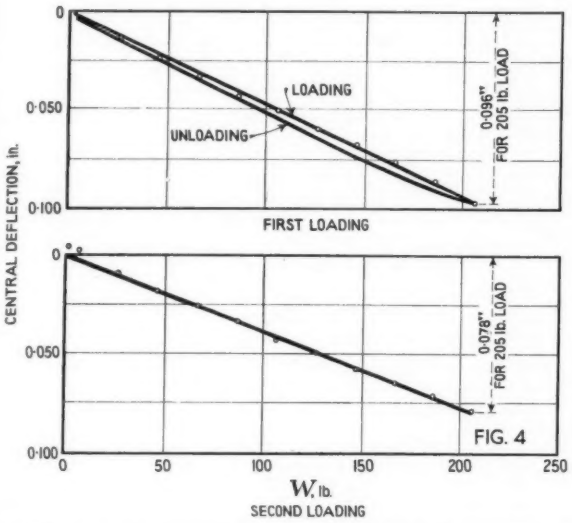


FIG. 4

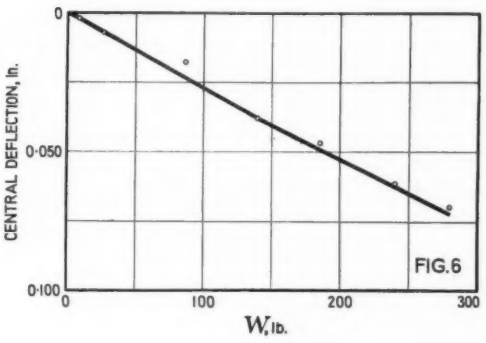


FIG.6

lengths for the compression members. This is equivalent to using higher permissible stresses.

Progress in this way is fairly safe, provided the adjustments made from time to time are not too drastic. It is, however, very slow, and a better fundamental understanding of the structure is required. This can only be obtained by measurements on actual structures.

The Model Lattice Girder

Prior to carrying out some work on a larger structure, the author has made and tested a model lattice girder. The model was made to simulate several bays of a plane frame near the base of a transmission tower, as shown in Fig. 1. The main chords of the model were made parallel. The bracing of the model was made up aluminium angles bent from 20 gauge sheet. By this means, because of the low Young's modulus, strain measurements are facilitated. The legs were mild-steel rolled angles. A comparison of the model and prototype is given in Table I.

A Comparison of Model and Prototype

The model is similar to the prototype. The l/r ratio

TABLE I.—DIMENSIONS OF ANGLE MEMBERS

		Length between bolt centres l	Cross section A	Least rad. of gyration r	Length/ rad. of gyration l/r	Leg width/ leg thickness b/t
		in.	sq. in	in.		
	Transmission tower					
Legs	5 × 5 × $\frac{5}{8}$ in.	72	5·86	0·97	80	8
	or					
	3½ × 3½ × $\frac{5}{16}$ in.	72	2·09	0·68	100	11
Bracing	2¼ × 2¼ × $\frac{3}{16}$ in.	84	0·81	0·44	190	12
	or					
	2 × 2 × $\frac{3}{16}$ in.	84	0·71	0·39	210	11
	Model					
Legs	(i.e. main chords of girder) 1 × 1 × $\frac{1}{8}$ in. mild steel	15	0·23	0·19	79	8
Bracing	0·58 × 0·58 × 0·036 in. aluminium...	15·75	0·040	0·12	130	16

of the main legs is the same—about 80. Since buckling is controlled by the Young's modulus of the material, the l/r of 130 for the aluminium bracing of the model is equivalent, if the members were steel, to an l/r of 390.

E for steel = 30,000,000 lb. per sq. in.

E for aluminium = 10,000,000 lb. per sq. in.

$$130 \times \frac{30}{10} = 390.$$

The equivalent figure for the prototype is about 200. The bracing of the model has been deliberately lightened in order that it may be the controlling factor. In most towers as at present designed, the leg members fail in load tests, and it is felt that the bracing is rather heavy. In the actual tower, the ratio of area of leg member to area of bracing member is 5·86/0·81 = 7·2, or 2·09/0·71 = 3·0. For the model, if we allow for the difference in strength of the aluminium and steel by multiplying in proportion to their yield strengths the ratio is $\frac{0{\cdot}23}{0{\cdot}040} \times \frac{35{,}000}{15{,}000} =$ 12·8. The bracing is again shown to be relatively light.

The above figures are intended merely as a guide to the relation between the model and prototype.

The connections in the actual tower consisted of $\frac{5}{8}$ in. or $\frac{3}{4}$ in. diameter black bolts in the main leg members, and $\frac{1}{2}$ in. diameter bolts at the intersection points of the bracing. The model thus calls for an $\frac{1}{8}$ in. diameter bolt. The strength of a strut is almost completely determined by the torsional and bending restraints at its ends, and these are dependent on the torsional and bending stiffnesses of adjacent members and on the connections between them. It is important in model studies to reduce to a minimum the variability of the connection. (This would also be an advantage in actual structures.)

The bolts used in the model were $\frac{1}{8}$ in. diameter metal threads (bolts having a rolled thread of 40 threads per inch). These bolts have been subjected to a great deal of work hardening during manufacture. In a pure tension test, bolts failed at loads of 600 to 660 lb. With a root area of 0·0064 sq. in., this corresponds to a stress of 100,000 lb. per sq. in. Screwing tests on these bolts gave consistent tensions of about 200 lb. at a torque of 12 in. lb. At higher torques, the thread strips.

Strength of the Bolted Connections

Tearing-out tests were carried out. Typical results are given in Table II.

TABLE II.—TEARING-OUT TESTS ON BOLTED CONNECTIONS

Type of test	Edge clearance (centre of hole to end of member)	Tearing-out loads
	in.	lb.
Aluminium bolted to aluminium	$\frac{1}{8}$	105, 105, 110
	$\frac{3}{16}$	140, 130, 130
	$\frac{1}{4}$	165, 170, 160
Aluminium bolted to steel	$\frac{1}{4}$	210, 225

Dry bolts and nuts were used. Greased bolts gave higher tensions at the same torque, and therefore higher tearing-out loads, but the results were inconsistent. A distance of $\frac{1}{4}$ in. from centre of hole to end of member was adopted.

Stress-strain curves for the aluminium and steel are shown in Fig. 2.

First Loading Test

The model truss was set up as a lattice girder and loaded as in Fig. 3, using dead weights. Load-deflection curves are shown in Fig. 4. At the loads used, the curves are linear and there is no permanent distortion, indicating complete absence of bolt slip.

The truss was set up again as in Fig. 5, and strains were measured on the members shown, using light Huggenberger mechanical strain gauges. A plot of strains was taken around the cross-section of the angle at four different points. Load-deflection curves are shown in Fig. 6 and the measured strains in Fig. 7. All the graphs are linear, showing that the elastic limit had not been reached.

There is considerable variation in the stress across the section (as shown by the measured strains), giving evidence of high bending moments in the members. Fig. 8 is a section through the members concerned, just above the leg angle. By integrating the stresses across the section, the forces in the members can be calculated. In Table III the forces in the members (per 100 lb. applied load) are obtained. A comparison with the force calculated from statics if the joints are assumed pinned, shows reasonable agreement. In each case the measured forces are rather less, as some of the load is taken by bending of the main leg. There is agreement with the usual design assumptions. The bending due to the rigidity of the joints is never sufficient greatly to alter the total forces in the members, but a comparison of the average stress and the measured stresses (Table III) shows that bending can increase the stresses by up to 90% in the elastic range. "Experimental load" was obtained by integrating measured strains, taken at the positions shown in Fig. 8, over the area. The "calculated load" was obtained from statics, assuming pinned joints.

Second Loading Test

The truss was set up again as in Fig. 9, and loaded to failure, using a screw jack and proving ring. At 320 lb. load, the lower half of member L3 U2 began to fail by twisting just away from the bolts, and buckling about its minor axis in the central portion. The upper half or U1 L2 behaved in a similar way. The members which failed showed considerable deflection at constant load due to creep in the aluminium. There was some spring in the loading system, and these members were permanently deformed. It is interesting to note the members which failed (thus determining the load capacity of the truss). They are shown dotted in Fig. 9.

It was found previously that the forces in the lower sections of L3 U2 and L3 U4 were the same, but the stress distribution was considerably different, L3 U2 being the more highly stressed. L3 U2 is the member which is bolted to the outside of the main angle; L3 U4 is bolted inside. In the truss as loaded, L3 U2 and U1 L2, the two members bolted on the outside of the main legs buckled in compression, whereas the

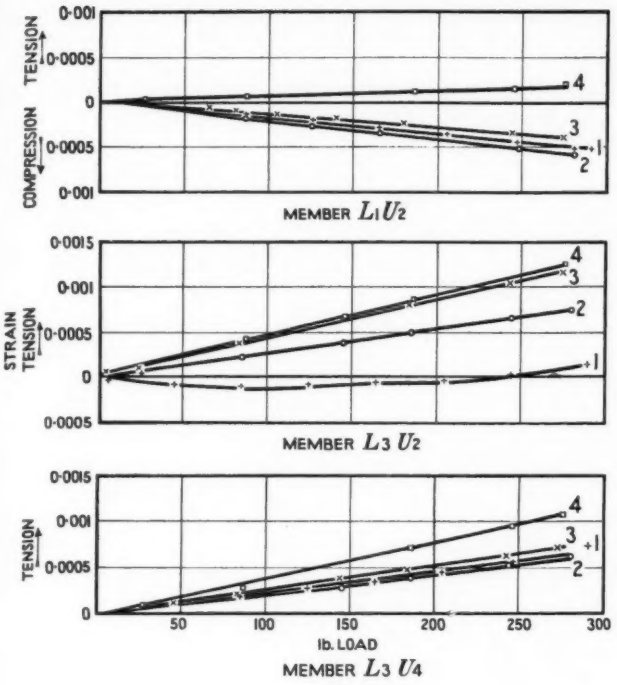


FIG. 7

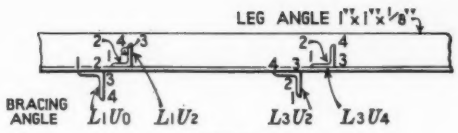


FIG. 8

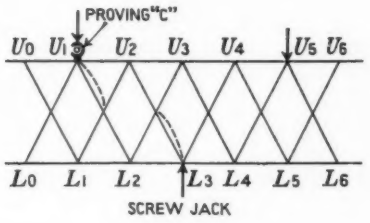


FIG. 9

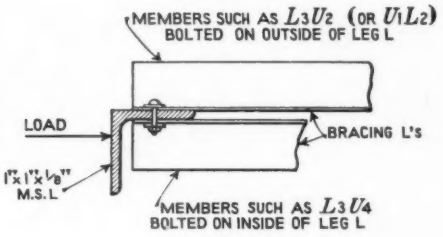

MEMBERS SUCH AS L_3U_2 (OR U_1L_2) BOLTED ON OUTSIDE OF LEG L
LOAD
BRACING L's
1"x1"x⅛" M.S.L
MEMBERS SUCH AS L_3U_4 BOLTED ON INSIDE OF LEG L

FIG. 10

corresponding equally loaded compression members L3 U4 and L4 U5, bolted inside, did not fail and in fact remained elastic. The load-carrying capacity of these struts has been determined by the restraining moments and torsions at their ends.

With the loading system used, the transverse location of the point of application of the load on the main leg will be important. It is apparent that the bending of L3 U4 and L3 U2 (favourable to L3 U4 and unfavourable to L3 U2) can only be caused by twisting of the leg angle, and this will be influenced by the location of the load point (Fig. 10).

Southwell Plot of Strains

Strains measured on the corners of the angles L3 U2 and L3 U4 are plotted in Fig. 11, and prove to be rectangular hyperbolae. The plot of ϵ/P against ϵ is shown in Fig. 12. ϵ = measured strain, P = calculated axial force in the member, assuming the joints pinned.

The ϵ/P against ϵ graphs are straight lines in each case. The lines lie fairly close together and are parallel. It has been shown that the inverse slopes of these lines represent a critical load for the members concerned. In the case of L3 U2, the inverse slope is 230 lb.; for L3 U4, it is 240 lb. These load values are the asymptotes at which the strain (Fig. 11) goes to infinity, and are the loads at which a perfectly straight member of high yield strength would buckle. Because of crookedness, etc., the strains become large before

TABLE III.—STRAINS, STRESSES AND FORCES IN MEMBERS

Member	Position	Strain	Stress $E=9\times10^6$ lb./sq. in.	Average stress	Experimental load	Calculated load
		$\times 10^3$	lb./sq. in.	lb./sq. in.	lb.	lb.
L1 U2	1	0·177	1590 compr.	1073	42·8	57
	2	0·214	1930 compr.			
	3	0·150	1350 compr.			
	4	0·065	590 tension			
L3 U2	1	0	0	1246	49·9	57
	2	0·127	1145 tension			
	3	0·206	1860 tension			
	4	0·220	1980 tension			
L3 U4	1	0·134	1210 tension	1358	54·3	57
	2	0·120	1180 tension			
	3	0·138	1250 tension			
	4	0·198	1790 tension			

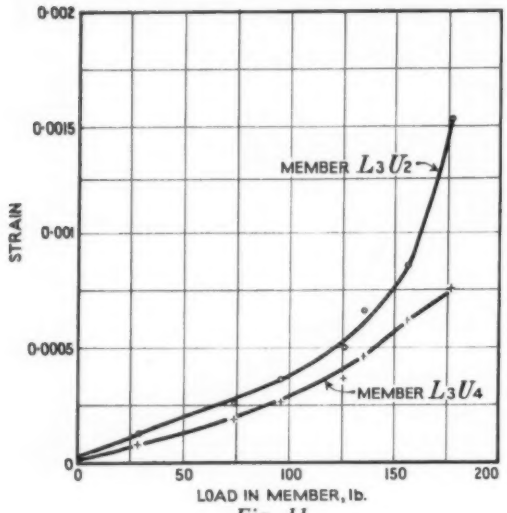


Fig. 11

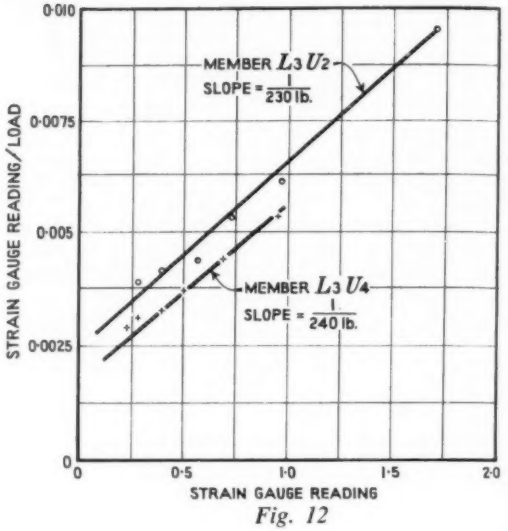


Fig. 12

this value is reached. It is important to note that this critical load is the same for each member L3 U2 and L3 U4, even though one failed and the other remained elastic.

For the 0·58 × 0·58 × 0·036 in. aluminium angle members concerned,

$I_{min.} = 5{\cdot}6 \times 10^4$ in.^{4}

Lengh between bolts = 15·75 in.

$$\text{Euler load} = \frac{\pi^2 EI}{l^2} = 200 \text{ lb.}$$

The critical load for L3 U2 and L3 U4 is about 235 lb. This may be interpreted as meaning that they have an effective pin-ended length of $\sqrt{\frac{200}{235}} = 0{\cdot}9$ of their actual full length, if they are considered as buckling about their minor axes. This is reasonable, in that the bracing angles are firmly bolted to the leg angle at one end, but only bolted to each other at their intersections.

The maximum force attained in the members L3 U2 and L3 U4 was 178 lb. This corresponds to an average stress of 4,400 lb. per sq. in.

Taking a load factor of two, a reasonable value for the permissible axial stress for design would be 2,200 lb. per sq. in. This is for a total l/r of 130 (Table I), or an effective l/r of $0{\cdot}9 \times 130 = 120$. At this l/r, B.S. 449 allows a stress of 1·62 tons per sq. in. (= 3,600 lb. per sq. in.) in single-bolted steel angles. With aluminium having one-third the Young's modulus and one-third the yield strength of steel, a design stress of 2,200 lb. per sq. in. would not be permitted by a code having the same basis as B.S. 449.

Conclusion

The tests carried out on this model have served to emphasise the factors which control the load-carrying capacity of bolted angle struts, in particular, the end torsional and bending restraints. Further research on the strain/load against strain plot may give information useful in design.

It is not claimed that model tests will give results of immediate practical utility. In fact, though it simulated the lower frames of a transmission tower, the model was loaded as a lattice girder. Bending and torsional restraints will also be different in the space frame.

There are many difficulties associated with full-size testing. One is the question of accurate, controllable loading. It may be possible to overcome this by building two adjacent towers, and jacking one against the other. With a model, certain difficulties associated with strain and deflection measurement are reduced, but greater accuracy is needed because of the small size. It is felt that model tests are a useful preliminary to the testing of a larger structure.

REFERENCES

Southwell, R. V., "On the Analysis of Experimental Observations in Problems of Elastic Stability," *Proc. Royal Soc.*, London, Series A, Vol. 135, p. 601.

Timoshenko, S., "Theory of Elastic Stability."

Harrison, H. C., "Wind Forces on Overhead Conductors" (S.E.C., Victoria).

Murray, N. W., *Proc. I.C.E.*, London, April 1956 and June 1957.

di Castelbianco, F. B., "Five Years' Experience in Tower Testing at the Lecco (Italy) Station."

Safety Guide. The Federation of Civil Engineering Contractors have issued a 40 page Safety Guide setting out recommendations on those safety precautions which have proved to be the most important from an analysis of over 3,000 accidents on civil engineering sites. It is in pocket size, strongly bound and contains an excellent index; it is obtainable from the Federation at Romney House, Tufton St., Westminster S.W.1, at 1s. per copy.

D.S.I.R. Lending Library. The Lending Library Unit of D.S.I.R. has started to collect Chinese scientific literature. About 150 Chinese periodicals are now being received at the Library's London premises. Already the Lending Library Unit has accumulated a large collection of Russian scientific literature, which is available to research, industrial and other organisations, through a loans service. The Library also organises a scheme for the translation of Russian scientific literature, in collaboration with the National Science Foundation in the United States. This may possibly be extended in the future to include scientific literature from China.

Fig. 17. Picote underground machine hall in service

Picote Station

This 180 MW development on the International Douro is Portugal's latest station to come into service, and embodies some unique features of design

PART TWO

IN our previous article we discussed the design and construction of the very unusual dam at Picote. We will now turn our attention to the underground works and the mechanical and electrical equipment.

Auxiliary Discharge

The auxiliary discharge, which, as we have already mentioned, has a capacity of 600 cu. m. per sec., is a circular steel and concrete-lined tunnel 5·5 m. in diameter and about 105 m. long, the entrance portal being about 49 m. below the normal retention level of the reservoir. It is succeeded by a length of about 62 m. of open channel, the mouth of which is shaped to throw a jet well into the air over the centre of the river bed. A sector gate at the outlet from the tunnel section is used for normal control. It can be operated automatically to relieve minor floods, and can also be hand controlled to make up the guaranteed flow to the downstream Spanish stations when the flow from the generating units is insufficient. A caterpillar gate near the intake enables the tunnel to be drained for inspection and maintenance.

Turbine Intakes and Penstocks

Each of the three turbines has its own intake and penstock. The intake structure has three openings 5·5 m. wide by 7 m. high, protected by movable grids and closed by caterpillar-type gates. The penstocks, which slope down to the power station, are 5·5 m. in diameter and about 100 m. long. They are lined with concrete, which is supplemented by a steel lining over the downstream 60 m.

Machine Hall

The machine hall, which involved an excavation of about 40,000 cu. m., is 88 m. long including the crane parking bays, 16·6 m. wide, and 35 m. high from the bottom of the draft tubes to the upper surface of the arch.

To expedite construction the excavation was attacked at three different levels; roof, turbines, and draft tubes. A rising adit, large enough to accept 1 cu. m. dumpers, was driven to roof level and the arch was cut the full length of the hall and then concreted on the retreat. A particularly interesting feature of the construction is that the crane runways, instead of being supported from below on pillars, are suspended from the roof arch and cast integral with it, the load being taken by the keying action of the arch into its rock abutments.

Concurrently with the work on the roof, the main attack was developed through a main access tunnel, about 240 m. long and on an 8% downgrade, driven to turbine level, the cross section being large enough

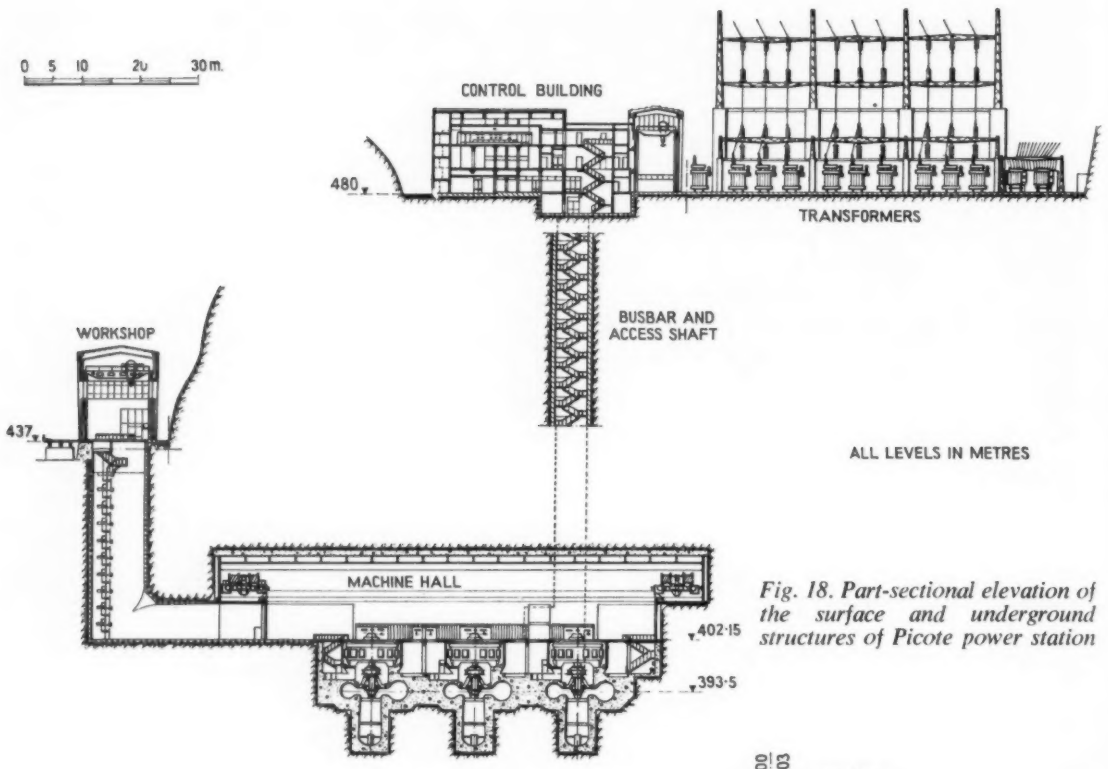


Fig. 18. Part-sectional elevation of the surface and underground structures of Picote power station

Fig. 19 (below). Plan of Picote underground machine hall and associated works

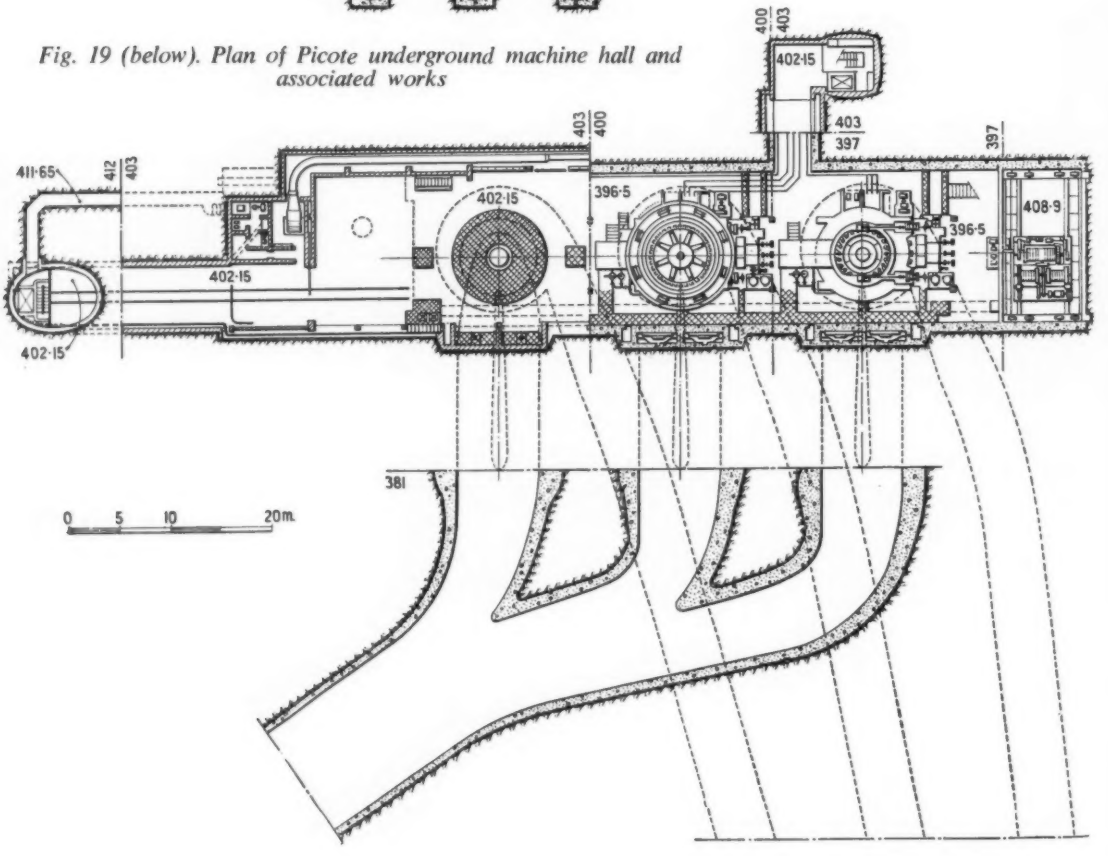


Fig. 20. Intake for the auxiliary discharge under construction. The shut-off gate gantry for the diversion tunnel can be seen on the right

Fig. 21. The auxiliary discharge in operation

to carry Eimco loaders and 20 ton Euclids. From this roadway headings were driven down the length of the machine hall, pilot headings were carried through the penstock tunnels, which were subsequently opened out to full section from the top downwards, and the lower portions of the two vertical access shafts were excavated. When the machine-hall roof had been concreted, three shafts were raised from the lower headings and the rock core within the machine hall broken down, the spoil being dropped down the shafts and taken away by Euclid trucks through the main access tunnel.

A third access tunnel, about 100 m. long, branching off from the main one at a gradient of 30%, was driven to draft-tube level at the point where the three draft tubes converge into the common tailrace tunnel. From this roadway the three draft tubes and turbine pits were cut out and the inner face of the tailrace-tunnel excavation commenced. In the meantime the main excavation for the tailrace tunnel was carried in from the outlet end.

An interesting problem arose in completing the excavation of the tailrace tunnel, for the exigencies of the layout made it necessary for this tunnel to pass immediately below the temporary diversion tunnel; indeed the roof of the tailrace tunnel at the point of crossing actually encroaches on the floor of the diversion tunnel. Except for a bottom pilot heading, the rock pillar below the diversion tunnel at the crossing was therefore left intact until that tunnel had been closed, drained and plugged. Then six shafts were raised from the bottom heading to meet a top heading, the floor of the diversion tunnel at the crossing was broken out and concreted, and the tailrace tunnel completed to full section.

Generating Plant

The generating plant consists of three 60 MW vertical Francis sets. The turbines, which were built by Ets. Neyrpic, Grenoble, and by Sorefame (Sociedades Reunidas de Fabricaçoes Metalicas), of Amadora, Portugal, have a nominal rating of 84,000 h.p. at a mean net head of 70·4 m., but have an actual overload capacity of 93,000 h.p. To reduce the overall height of the set the thrust bearing is mounted on the turbine cover.

The alternators are of Sécheron manufacture, and have a normal full-load rating of 60 MW at 15 kV, 0·9 p.f., and 166·7 r.p.m., but they can sustain a continuous overload of 10% when the cooling water pumped from the river does not exceed 15°C. Each rotor, excluding the turbine runner, weighs about 230 tons and has a flywheel effect of 7,250 ton-m.^{2}, being designed for a runaway speed of 345 r.p.m.

The machine hall is served by two 120 ton cranes, which are together capable of lifting the rotor. One of these cranes has an auxiliary 35 ton hook.

Copper busbars and control cables are brought up a distance of about 150 m. through the access shaft, 80 m. high, to the three-storey control building near the top of the dam. The control room is on the third floor with the cable room immediately below it. The busbars emerge on the ground floor, where there are two 1,000 kVA 15 kV/400 V three-phase EFA transformers for the auxiliary services, together with the auxiliary switchgear, battery, and standby diesel-electric set. The remaining rooms on the second and

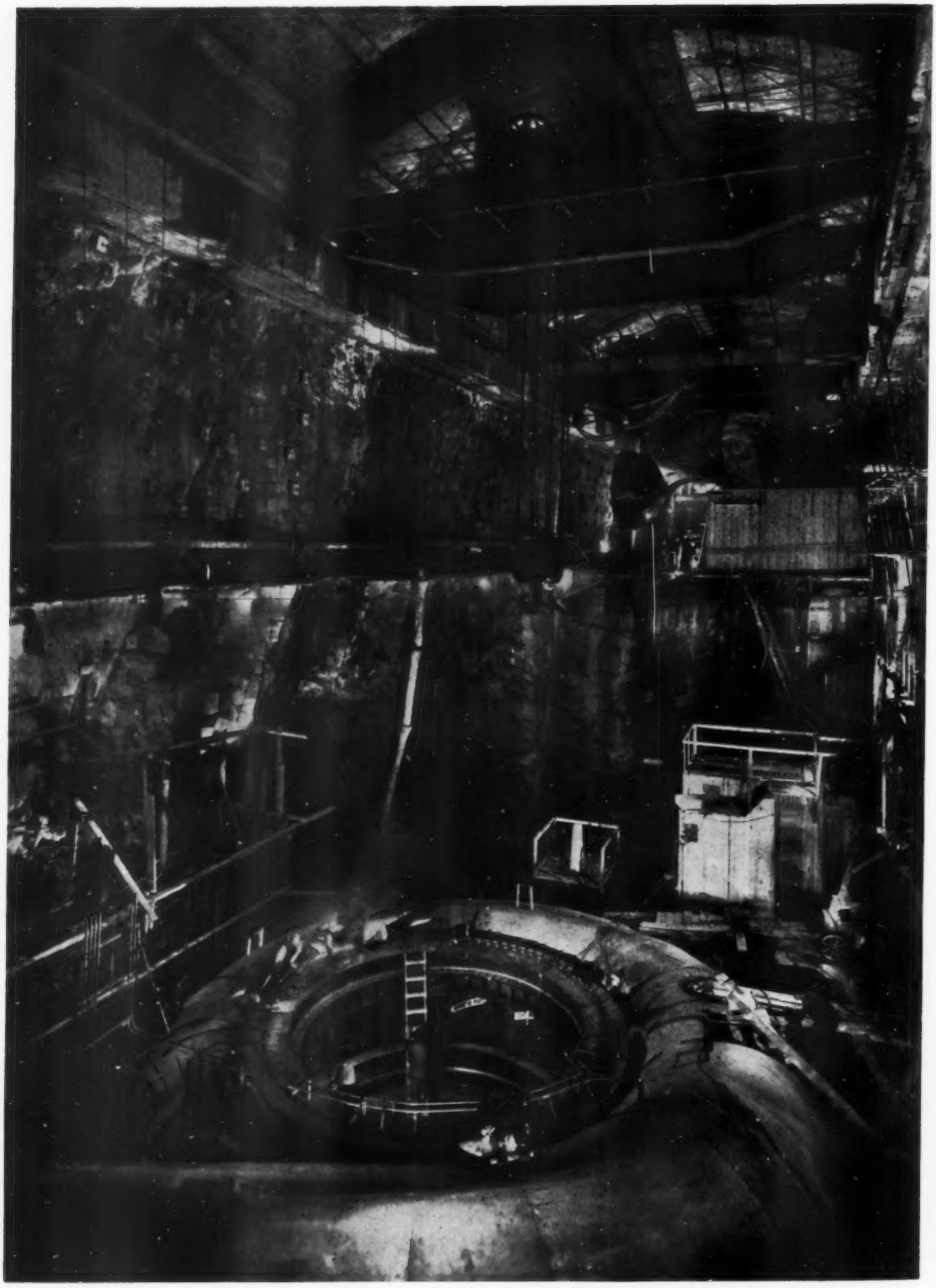


Fig. 22. Picote underground power station under construction

Fig. 23. A general view of the control room

third floors are devoted to the laboratory, telephone exchange, and the usual offices.

At one end of the control building is a set of outdoor cubicles for the main transformers, which comprise ten single-phase 25 MVA CEM units, making three 15/230 kV three-phase banks with one unit spare.

As previously mentioned, to minimise levelling work on this precipitous site, the switching station has been placed towards the brow of the hill about 600 m. away from the transformer station, to which it is connected by overhead line. It is on the double-busbar system and is controlled by Sprecher & Schuh minimum-oil-type circuit breakers. To allow for

Fig. 24. The open-air switching station on the plateau

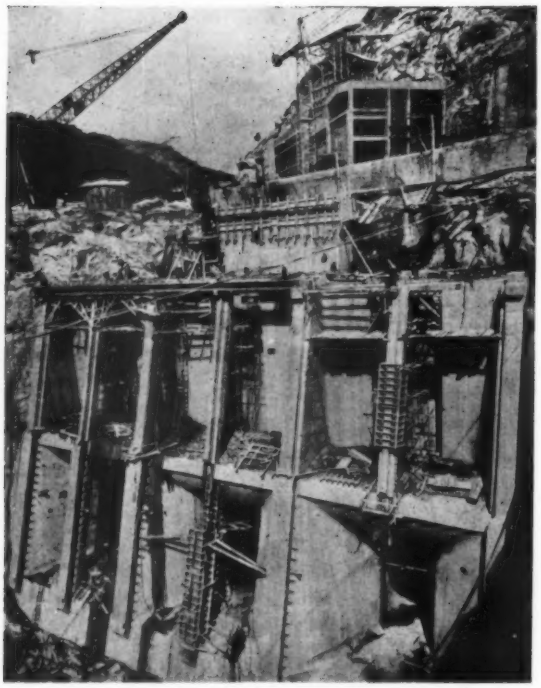


Fig. 25. The turbine intake structure

possible future interconnection with the Spanish system these units have a rupturing capacity of 5,000 MVA.

A transmission line, 240 km. long, has been erected from Picote to Coimbra, operating at 220 kV, which is the highest voltage yet employed in Portugal. A second line at the same voltage is later to run from Picote to Oporto, a distance of 206 km.

Picote station is expected to yield an average annual production of about 1,000 GWh.

Acknowledgments

We are happy to acknowledge our indebtedness to Eng. Paulo de Serpa Pinto Marques, President of Hidro-Eléctrica do Douro, for his courtesy in affording us facilities to visit the Picote and the Miranda developments and in placing at our disposal all needful information and illustrative material for the preparation of this article. Indeed, we greatly appreciated the time that Senhor Marques and his senior staff placed so unstintingly at our disposal in our quest for knowledge. Of the staff members who assisted we should particularly like to thank Eng. Daniel Pinto da Silva, who accompanied us on our tour and was helpful in the highest degree.

Fig. 26. One of the houses built for the use of officials

Contractors and Suppliers

Civil-Engineering Contractors
Sociedade de Construçoes ETELI-OPCA Ldª., Oporto.

Diversion Tunnel Contractors
Obras Públicas e Cimento Armado (OPCA), Oporto.

Concrete Preparation Plant
Blaw Knox Ltd.

Blondin Cableways
John M. Henderson & Co. Ltd., Aberdeen, Scotland.

Turbines
Neyrpic, Grenoble.
SOREFAME, Amadora.

120 ton Cranes in Machine Hall and 35 ton Crane in Surface Workshop
Companhia União Fabril (CUF), Lisbon.
Ridinger, Mannheim.

Alternators
Sécheron S.A., Geneva.

Main Transformers
Compagnie Electro-Mécanique (CEM), Le Havre.

Auxiliary Transformers
EFA—ACEC, Oporto.

Main Circuit Breakers, Main Control Board and Auxiliary Switchgear
Sprecher & Schuh Ltd., Aarau.

Cables
Fábrica de Condutores Eléctricos Diogo D'Avila, Ldª., Lisbon.
Fábrica Nacional de Condutores Eléctricos, SARL (CEL), Lisbon.

Rock Drills
Atlas Copco, Sweden.
Minas e Metalurgia, Lisbon.

Excavators
Link Belt Speeder Corporation, U.S.A.
Marion Power Shovel Company, U.S.A.

Loaders
The Eimco Corporation, U.S.A.

Euclid Trucks
Euclid (Gt. Britain) Ltd.

Aggregate Crushing Plant
Nordberg Manufacturing Co. Ltd., England.

Grading Plant
Frederick Parker Ltd., England.

Concrete Cooling Plant
International General Electric Company.
Sillcox Refrigeration Corporation.
Frick Company, Inc., U.S.A.
DANFOS Manufacturing Company, Denmark.

Water Treatment Plant
Sociedade de Estudos Técnicos, Ldª., Lisbon, under patent by Prosimacfi S.A., France.

Smooth Blasting

A study of the technique developed for the smooth blasting of water tunnels, open cuts, underground machine halls, and other chambers in rock

By ULF LANGEFORS*

FORMERLY, when gunpowder was used for blasting, fine, even contours could be obtained in the rock; this effect can be observed, for instance, in certain old forts. When the use of high explosives, especially dynamite, was introduced in rock-blasting, the rock which was left standing was very rough and broken, and there were thus large volumes of surplus rock. This situation was long accepted as an evil, but inevitable, result of modern practice. In recent years, however, investigations in laboratories and on sites in Sweden have shown that, in modern rock blasting, it is possible to make the final contour appear almost as if it were cut out of the rock and to leave the remaining material practically undamaged. This method for accurate blasting in underground premises has been given the name of smooth blasting, or simply smothing.[1, 3]

Apart from mines, most of the underground projects which are being constructed in rock in Sweden are of a permanent character. A number of them include important buildings such as workshops, power stations, staff premises, oil stores, etc. A great deal of inconvenience and expense is generally incurred in such undertakings if blocks of stone have to be removed after completion of the work or chipping of the face, and further safety measures have to be taken. Experience from works executed during the past fifteen years has shown that much time, trouble and money can be saved by careful blasting of the rock contours. In the construction of water tunnels, overbreak is reduced and the hydraulic friction is so much lower that lining to secure a smooth surface is unnecessary. There are also other, chiefly constructional reasons, for taking every care in blasting sections for rock premises. Nowadays supporting concrete vaults are largely used, these being carried up so close to the rock roof that it cannot be inspected once the interior of the building has been completed. In this form of construction it is highly desirable to blast the roof of the rock as close to the theoretical section as possible so that the height of fall will be as small as possible should any blocks become loose. The same demands for accurate blasting apply to so-called metal concrete cisterns of the Sentab or Fort F type, where all cavities caused by surplus rock have to be filled up with concrete. The economics and aesthetics of spraying the roof with concrete, where desired, also depend on accurate blasting.

Among the tests carried out to obtain smooth crack-free rock faces were the practical experiments by Hagthorpe and Dahlborg at one of the underground establishments in the Stockholm area belonging to the Royal Fortification Administration, preliminary tests on rock by the Physical Research Laboratory of the Nitroglycerin A.B. in collaboration with the Stockholm Harbour Board and plexiglass scale-model blasting by Langefors and Lundborg.[1] Similar tests have been made by the Royal Fortification Administration in collaboration with Nitroglycerin A.B. and Atlas Copco A.B.[3] The investigations answered some of the essential questions and led among other things to the production of charges specially suitable for smooth blasting.

* Nitroglycerin AB, Stockholm.

Reduction of Cracking

To ensure a good-quality rock face, the cracks outside the blasting contour, and especially the cracks which originate from the contour holes, must as far as possible be kept within reasonable bounds. Several factors must be considered to achieve this.

In the first place, the section of rock which is to be blasted should not be too tightly wedged, for in such a case an unnecessarily large quantity of explosive would be required, resulting in strong vibrations and considerable cracks in the surrounding rock.[2] The placing of holes and the detonating sequence must be chosen so that the rock is blasted away successively with breakage towards free surfaces (Fig. 1).

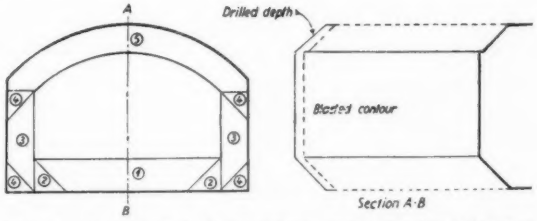


Fig. 1. Appropriate detonating sequence for blasting of roofs and walls in tunnels with minimum damage to the remaining rock

For the blasting of the actual contour holes it is important to use the correct size of charge and to adjust its concentration correctly in the drill hole (Fig. 2). The size of the charge determines, among other things, the length of the cracks which penetrate into the surrounding rock from the drill hole. On the other hand the number of cracks depends principally on the concentration of the charge in the hole (Fig. 3). In using the smaller charge concentration the plexiglass is slightly damaged round the drill hole, and only a few cracks have extended to the full length. To a certain extent, these cracks can be guided in definite directions through special unloaded guide holes, thereby giving an even and satisfactory final contour (Fig. 4b).

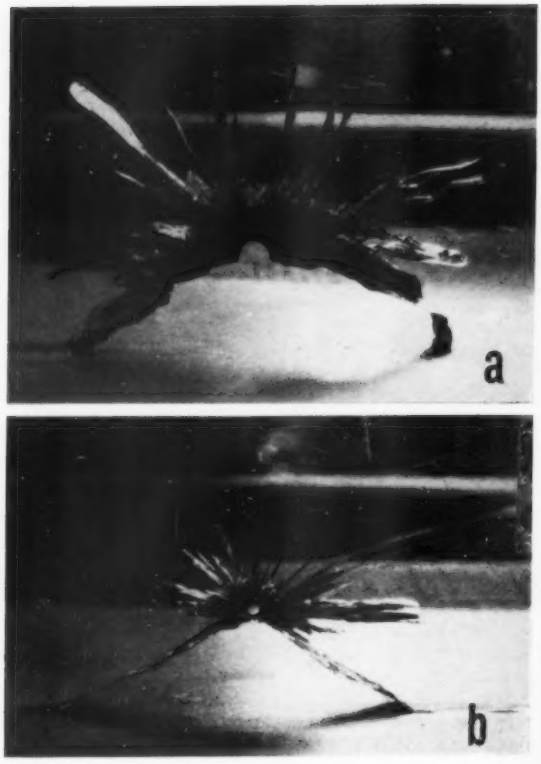


Fig. 2. For minimum stress on remaining rock it is essential to avoid overcharging. In this scale model the same burden has been blasted with different sizes of charge. In a *a charge has been used four times larger than the correct one in* b

Burden and Distance of Holes

How should the burden and the distance of holes be adjusted to give the best results for smooth blasting?

Scale-model blasting, as well as practical blasting experience,[3] shows that the quality of the remaining rock face is largely dependent on the relation between the distance of the holes E/V and the burden. If a good result is desired E/V should be $\leq 0{\cdot}8$, i.e. the burden should not be too small compared with the hole distance.

The upper picture in Fig. 4 shows a scale model experiment, in which $E/V = 2$. This high value for E/V has resulted in a very uneven final contour and, in addition, has left a wall which is seriously damaged by large cracks. A wall face with such cracks would obviously not be strong enough.

In the lower picture in Fig. 4, $E/V = 0{\cdot}5$, the quantity of "rock" per drilled metre is the same as in Fig. 4*a*, but as only every third hole was loaded the size of the charge per unit of volume is only one-third of that in Fig. 4*a*. In Fig. 4*b* the easiest course for the cracks has been through the holes, the uncharged holes also favouring the cracking along the intended final contour which proved to be very even. If all the holes had been charged, i.e., if the size of charge had been the same as in Fig. 4*a*, there would have been a larger number of crack roses but a considerably better final contour than in Fig. 4*a*.

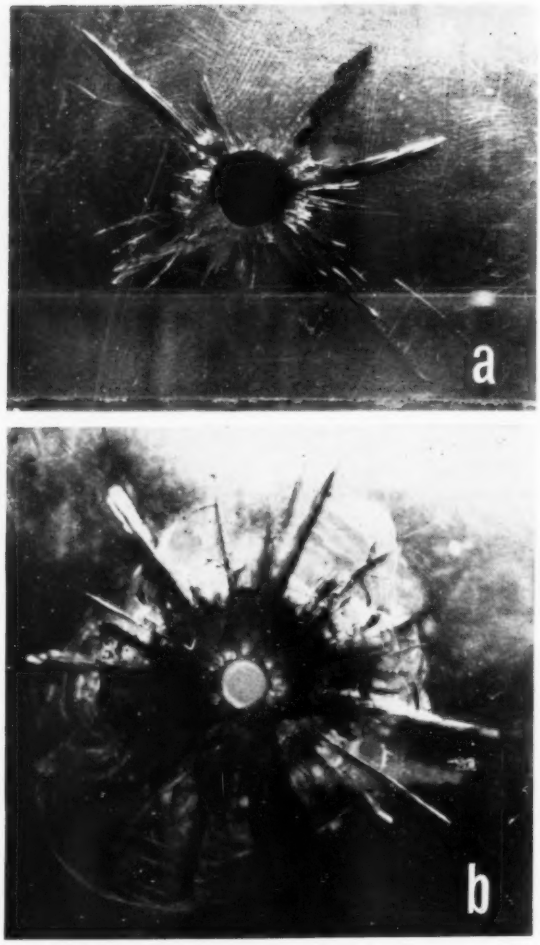


Fig. 3. More cracks are obtained with the same charge when it etirely fills the hole. In a *the volume of the hole was four times larger than in* b, *but the charges were the same*

In full-scale rock blasting the effect of uncharged guide holes (Fig. 4*b*) is greatest if the guide holes are placed from 10 to 20 cm. from the charged holes. The distance between the charged holes can then be 60 to 80 cm. Normally, uncharged guide holes are unnecessary except in special cases, e.g., when it is desired to obtain contours with a small radius of curvature (connection between wall face and roof, or something similar).

Charging of Contour Holes

Special contour hole charges intended for smooth blasting are now available on the market. They consist of pipes about 0·5 m. long with a blasting charge of gurite (Fig. 5). The charges can be joined together by sleeves to obtain the desired lengths and the external diameter at the joints would then be 18·5 mm. The gurite pipe charges constitute a complete tool for smooth blasting of roofs and walls in tunnels, and of other underground premises, and by using them a gentle treatment of the finished rock face is ensured. Charges for smooth blasting can also be

made up from ordinary dynamite by cutting up the cartridges lengthways and putting them on a wooden rod so that the concentrated charge is less than 0·25 kg. per m. This can be done by using 25 mm. cartridges which after being cut up lengthways are placed 5 or 10 cm. apart on the wooden rod. Another charge which gives comparatively good results can be made with 10 cm. wooden pegs alternating with halved cartridges of LFB-dynamite.

Ignition

There should be as little time spread as possible in detonation between different holes in a row. In those cases where smooth blasting is carried out separately (after the rest of the round) the charges can be detonated by instantaneous electrical caps, short-delay caps of a lower interval number, or a detonating fuse. If the contour holes are part of a large round this cannot be done and the charges must then be detonated by electric caps of a high interval number with either a short delay or a half-second delay.

If the same delay number is used in doing this a certain spread in detonating time between the different holes will occur. Short-delay caps give a spread of ± 10 millisec., half-second delay ± 200 millisec. (0·2 sec.). Fig. 6 shows how the two methods of detonation affect the finish of the final contour. Short-delay blasting caps should be used if the best results are to be obtained, and this also applies to separate blasting of the

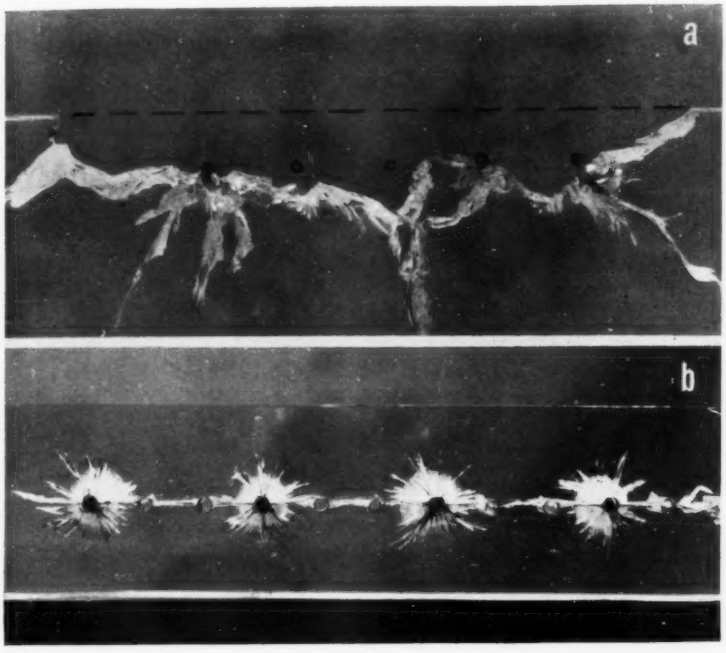


Fig. 4. With a given mass of rock per drill hole the burden must not be too small. In a *the burden was* V=*1 and the distance of the holes* E=*2. In* b *the corresponding values were* V=*2,* E=*1. In* b *can be seen the influence of guide holes in blasting homogeneous material*

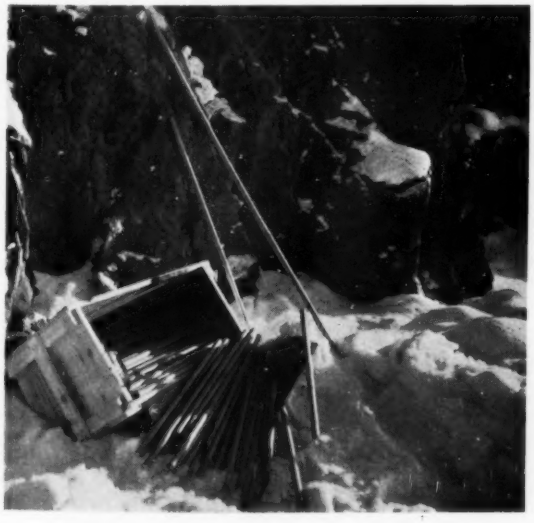


Fig. 5. Pipe charges for smooth blasting

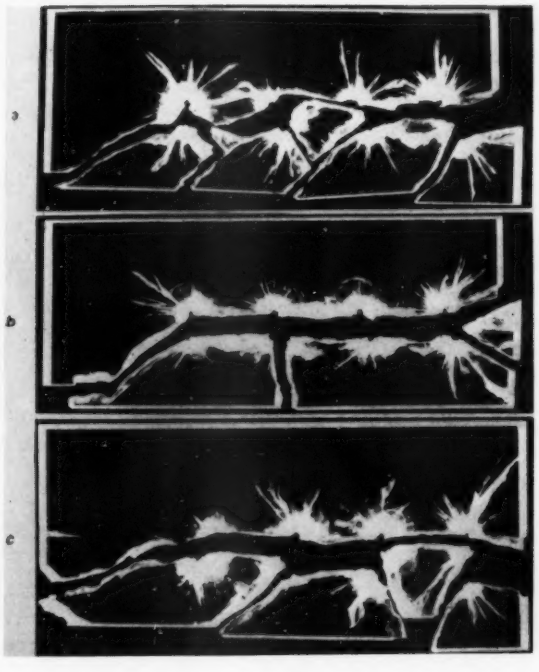


Fig. 6. Blasting of row of holes (experiment in plexiglass); a *shot by shot;* b *instantaneous blasting;* c *short-delay blasting*

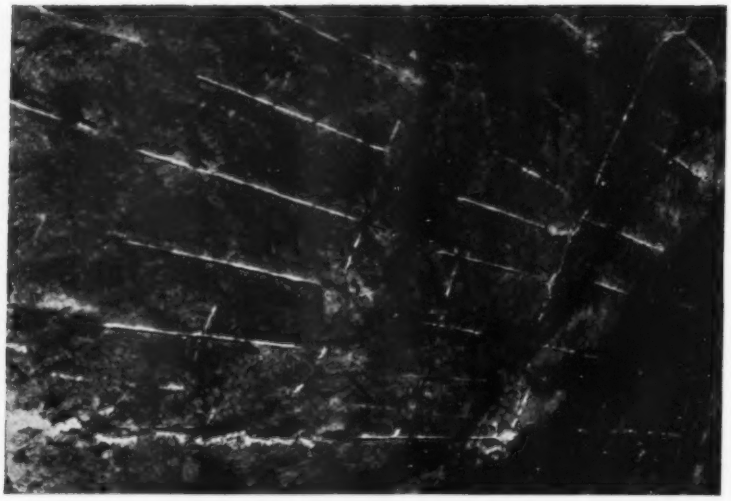


Fig. 7. Close-up of rock face blasted with gurite pipe charges for smooth blasting. A correctly adapted size of charge and short-delay detonators of the same interval number give the best results

final contour; in this way the increased stresses caused by instantaneous blasting are avoided. It is also important to keep the detonating spread to the minimum because if it is of the order of 100 millisec, the charges which are fired first may blow out charges from neighbouring holes before they are detonated.

Fig. 7 shows a close-up of a rock face which has been blasted with gurite pipe charges for smooth blasting, using short-delay detonators of the same interval number (No. 1). The drill-holes are unbroken up to where the bottom charge has been placed, marking the boundary line between two consecutive rounds.

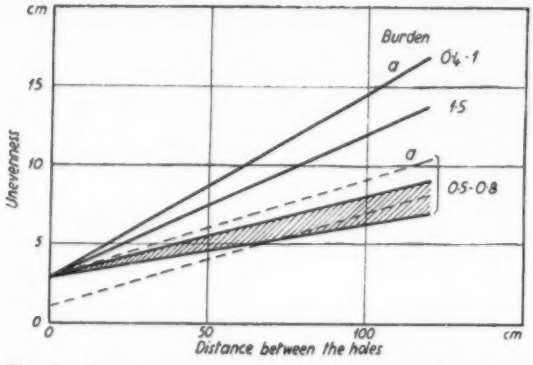


Fig. 8. Average unevenness of the rock contour as a function of the hole distance, the burden and the size of charge. Full lines refer to site A; dotted lines to site B which has exceptionally homogeneous rock. Curves a, *large overcharge; other curves, correct charge*

Planning of Smooth Blasting

Fig. 8 reproduces the results of experiments which have been carried out by the Royal Fortification Administration, Nitroglycerin A.B. and Atlas Copco A.B. The diagram shows the average unevenness of the rock face in relation to the distance of holes, the burden and the size of charge.

Fig. 8 can be used as a guide in choosing the burden and the distance between the holes when plans are being prepared for smooth blasting. The curves marked *a* show where overcharging has occurred and this should, of course, be avoided, particularly as large burdens involve heavy charges with unnecessary cracking in consequence. The shaded area in Fig. 8,

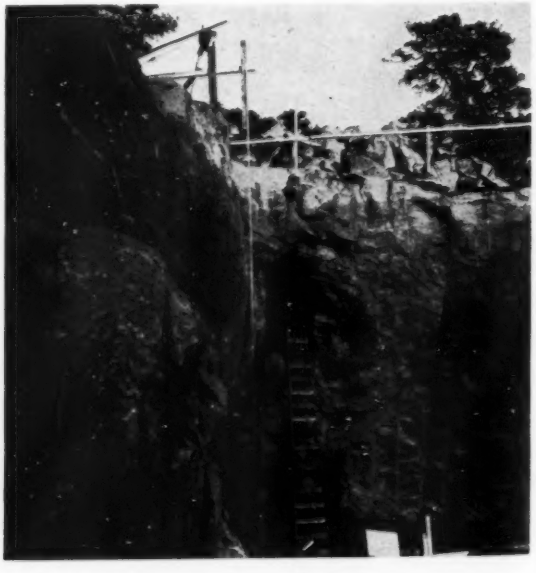


Fig. 9 (left). Tunnel roof in unhomogeneous rock, free from large cracks and crevices (AB Sk. Cementgjuteriet). Fig. 10 (right). A smooth-blasted bench wall (Royal Fortification Administration)

Fig. 11. Smooth blasting of roof and wall faces in Stornorrfors power station

Fig. 12. Smooth blasting in a narrow drift (Royal Fortification Administration)

representing blasting charges of $\leq 0{\cdot}25$ kg. per m., or gurite charges, is the one with which we are concerned from a practical point of view.

As will be seen from the lines for proper burdens 0·5–0·8 in Fig. 8, very little is usually gained in respect of the unevenness of the remaining face by spacing the holes less than 50–60 cm. apart. It is consequently not necessary to adopt extremely close drilling in order to obtain even and satisfactory rock faces. If very great evenness is desired in special cases, uncharged guide holes can be used (a small bottom charge might be necessary). The distance between the charged holes need not then be less than 60 cm.

Favourable results are obtained for gurite pipe charges in normal rocks by following these simple rules:

1. Distance of holes 60 cm.
2. Burden 80 cm.
3. Bottom charge 0·2 kg.
4. Short-delay detonators of lowest possible interval number.

The above rules apply for roof and walls, and for vertical holes in bench blasting where the rock mass has a free breakage. If this is not the case, e.g., where there is a load of previously blasted rock, the charges must be increased to ensure breakage. This means that in blasting tunnels, smooth blasting of the lower part of the walls may not be possible unless the spoil is removed before the smooth blasting is carried out.

Advantages and Examples of Practical Results

As Figs. 9 and 10 illustrate, homogeneous as well as

Fig. 13. A fine example of how the final contours required can be cut out of the actual rock by smooth blasting (Stornorrfors power station)

unhomogeneous rocks can be cut very accurately along the desired final contour by smooth blasting. Consequently:

1. Water tunnels will have lower hydraulic losses.
2. Roofs and walls will be stronger and less chipping will be needed.
3. There will be less risk of falling stones.
4. Concreting the actual rock face will be easier and will cost less.

If large cracks and crevices run right through the rock, the exposed rock face will have corresponding irregular features. The chief advantage of smooth blasting in these cases is that further large cracks are avoided and existing ones do not become larger.

Finally, Figs. 11 and 13 show some fine examples of blasting at Stornorrfors, where it has been possible to cut the final contours out of the rock. Needless to say such satisfactory results can only be achieved by skilful planning and careful supervision.

NOTE. This article was originally published in Swedish in *Teknisk Tidskrift*, and the English translation was provided by the author.

REFERENCES

1 Langefors, U., "Slätsprängning" (Smooth Blasting), *J.K.A.*, *137* (1953), 436.
2 Langefors, U., "Principles of Tunnel Blasting," WATER POWER, January and February 1955, pp. 9 and 63.
3 Bergman, S. G. A., "Noggrann utsprängning av bergrumssektioner genom s.k. slätsprängning" (Accurate Blasting of Underground Premises by so-called Smooth Blasting), *Byggmästaren 36B* (1957), 85.
4 Göransson, T., "Byggandet" (The Process of Building), *Tekn. Tidskrift 87* (1957), 1163.

Diesel Engine for Up-country Service

A description of a new range of stationary diesel engines may seem somewhat out of place in a journal devoted to water power, but even in the hydro-electric field the diesel engine has definite uses. In building any hydro-electric scheme a substantial block of construction power is needed, and there have been numerous instances where, in remote regions, it has proved more economical to erect a temporary local diesel-engined power station than to run a construction power line to the site. Then again, a number of supply authorities depending primarily on water power have found it to their benefit to supply certain isolated localities by diesel-engined stations, either permanently or until it became feasible to run a supply line to them.

For services of this kind the new "AT" range of medium-speed diesel engines developed by Ruston & Hornsby Limited, Lincoln, England, has much to offer, both in fuel consumptions that are definitely below those normally achieved in current practice, and in a form of mechanical construction that should guarantee an exceptionally high degree of service reliability. These claims are made on the basis that the new series is not an improved version of an existing range but is the outcome of a five-year fundamental study of diesel-engine design, using modern design techniques such as model tests and electronic-computer calculations. This study reviewed the long-term trend in the development of engines from 600 b.h.p. upwards, and aimed at laying down a specification which would leave ample margin for development up to the highest brake mean effective pressures

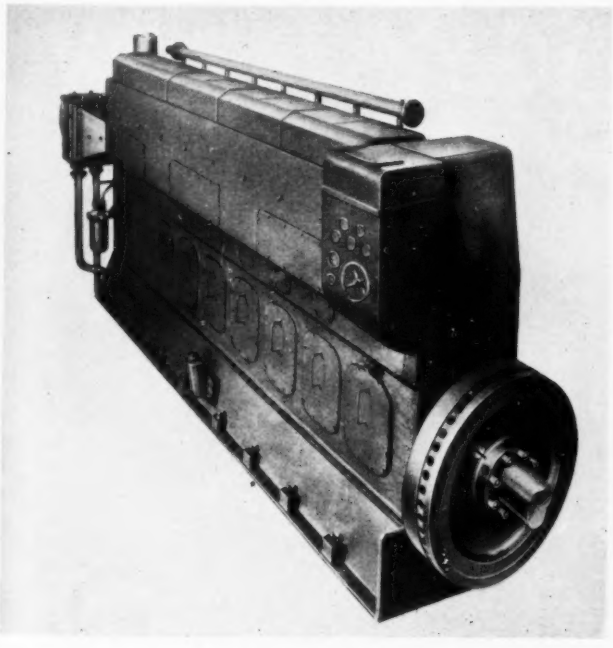


Fig. 1. Ruston "AT" range stationary diesel engine

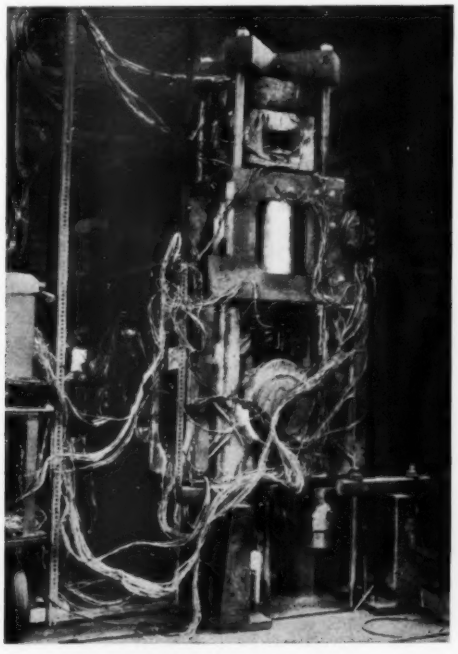
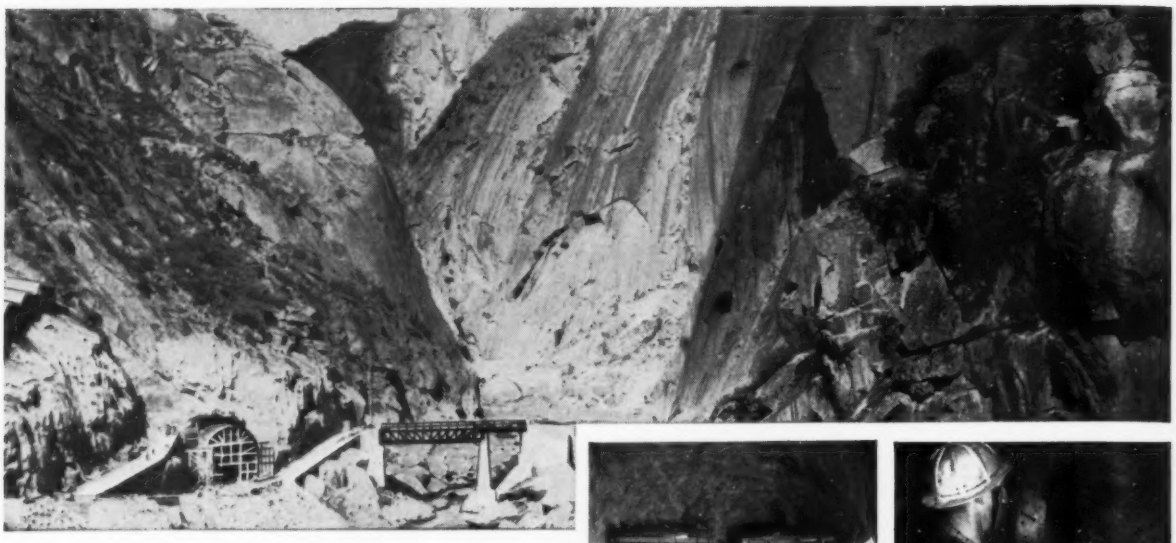
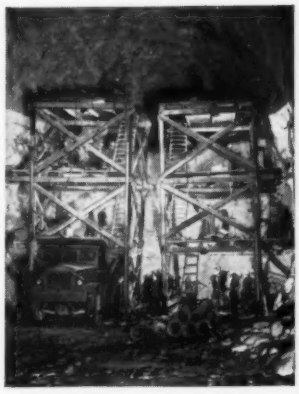
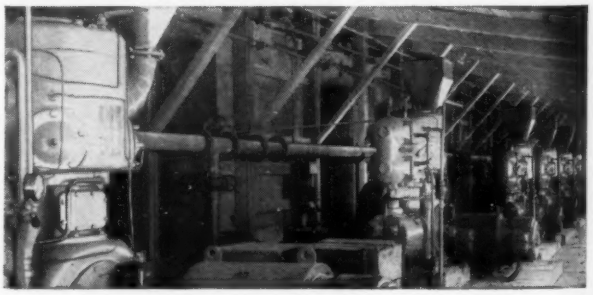


Fig. 2. Mock-up under test

WESTERN EUROPE'S LARGEST HYDRO-ELECTRIC POWER STATION







Atlas Copco pneumatic equipment and Sandvik Coromant drill steels for Spanish project

What is to be the largest hydro-electric power station in Western Europe is now being built by Iberduero S.A. at Salto de Aldeadávila. The great dam will finally tame the River Duero and enable Spain to increase her hydro-electric capacity by 25%.

ANNUAL OUTPUT — 1,700 MILLION kWh

The dam will form a reservoir for 150 million cu. yds. of water. The underground power station containing six units will have an installed power capacity of 762,000 kVA. Annual output of the project is estimated at 1,700 million kWh. This power station alone will give Spain a larger increase in installed capacity than the total national increase in hydro-electric energy during the period 1950-1954.

925,000 CU. YDS. OF ROCK TO BE EXCAVATED

All the rock drilling on the site is being done by 165 Atlas Copco rock drills using Sandvik Coromant drill steels. Tunnelling accounts for more than half of their excavation task which, in all, amounts to almost a million cu. yds. They are powered by a battery of 14 stationary compressors—types currently the leading choice for tunnelling projects throughout the world—the Atlas Copco AR3 and AR4.

MORE THAN 1,300 MILLION FEET DRILLED EVERY YEAR

Atlas Copco rock drills and Sandvik Coromant steels were developed to work together as a lightweight drilling unit. Responsible for drilling more than 1,300 million feet annually, this drilling combination is now the most widely used in the world.

A COMPLETE RANGE OF COMPRESSED AIR EQUIPMENT

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies or agents in ninety countries throughout the world.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden, or Atlas Copco (Great Britain) Ltd., Beresford Avenue, Wembley, Middlesex.

DSS 49 REVISED

likely to be used in the readily foreseeable future.

The "AT" range is based on a cylinder size of 12½ in. bore by 14½ in. stroke running at speeds up to 520 r.p.m. and supercharged by a blower driven by an exhaust-gas turbine. Brake mean effective pressures at present adopted are 125 lb. per sq. in. at 500 r.p.m. with a plain supercharger and 160 lb. per sq. in. when an intercooler is used. Engine frames are available having five to nine cylinders, the powers, at 520 r.p.m., ranging from 715 to 1,280 b.h.p. without intercooling and 910 to 1,645 b.h.p. with intercooling.

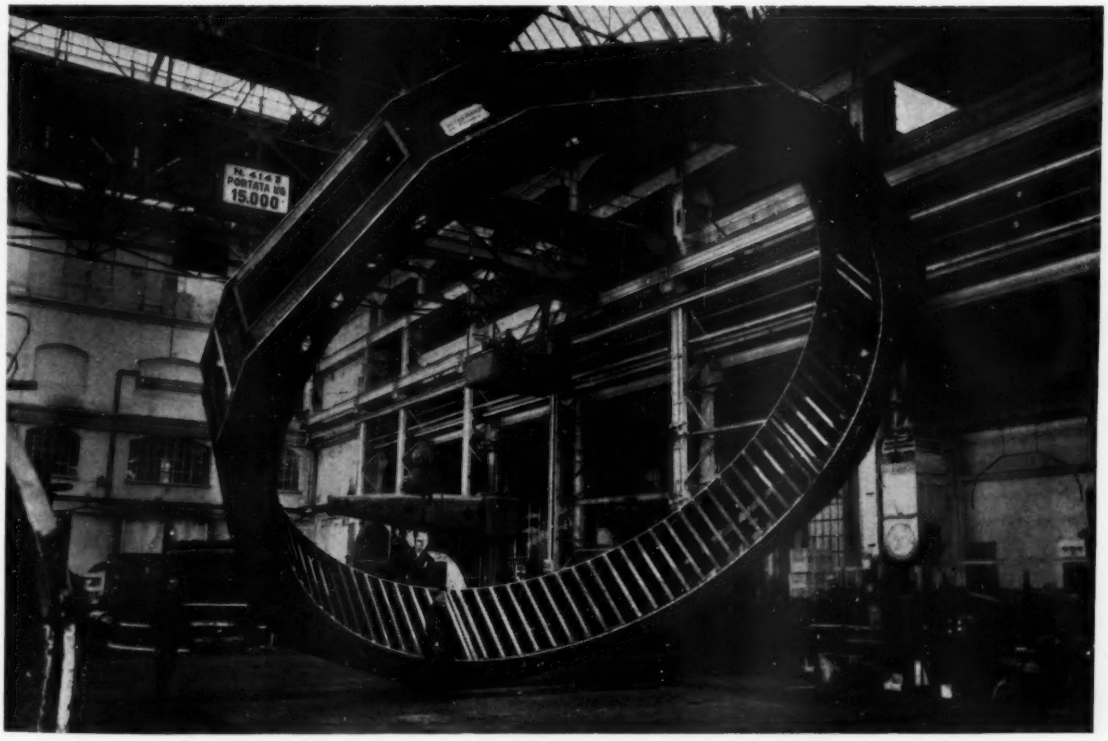
The design techniques to which we have referred are of more than ordinary interest. Well over 6,000 electronic-computer calculations were carried out on the operating cycle and were embodied in a series of three-dimensional charts. As a result it has been possible to achieve fuel consumptions of just over 0·35 lb. per b.h.p.-hour for the non-intercooled engine, and of well below 0·34 lb. per b.h.p.-hour for the intercooled engine.

On the structural side the stressing of every major component has been made the subject of a fundamental analytical and experimental study, and to assist in this a single-cylinder mock-up, depicted in Fig. 2, was built and subjected to exhaustive strain-gauge tests. One important result of these studies has been the development of a cylinder head with a four-stud fixing which has been shown to be far stronger than previous conventional fixings with six to eight studs. On the mock-up this fixing withstood a pressure of 3,000 lb. per sq. in. before showing any sign of leakage, although the maximum firing pressure is only 1,200 lb. per sq. in. A second important result of these investigations has been the development of an unusually rigid crankcase casting, in which the bearing deflections were studied qualitatively by silicone-rubber models according to a technique pioneered by Ruston & Hornsby Limited, and quantitatively by Perspex models under polarised light. These studies have reduced the bearing deflection to one-fifth of that in the original design.

Space precludes our dealing with many other design points of almost equal interest, but we feel certain that the techniques employed in the design of this engine will appeal to engineers in the hydro-electric field, and should give confidence in the suitability of the engine for service in isolated localities where fuel economy and exceptional reliability are prerequisites.

Alternators for Karnafuli

The accompanying photograph shows the stator for the first of two alternators which Tecnomasio Italiano Brown Boveri are building for Karnafuli power station, Pakistan. This station is being built on the Karnafuli river about 30 miles upstream from its mouth in the Gulf of Bengal, under the direction of International Engineering Company of San Francisco. The alternators will be rated at 57,500 kVA at 107 r.p.m., and will be the largest so far built in Italy. The diameter of the rotor is over 8 m. and the overall diameter of the stator is about 13·5 m. Both stator and rotor are divided into sections for transport.



Stator frame of one of the Karnafuli alternators in the T.I.B.B. works

VT

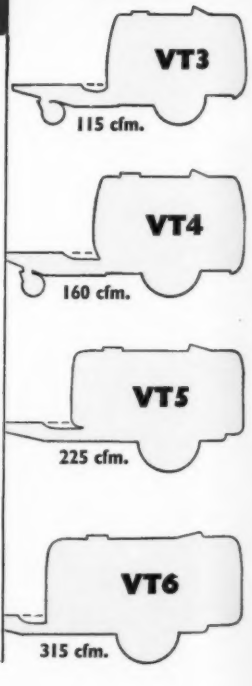
'PACKAGED POWER'

the world's lightest and smallest series of portable compressors– piston or rotary!

Spare parts for compressors and engines interchangeable throughout the series

Atlas Copco now introduce a range of VT compressors, all incorporating the major changes in design and production that made the VT4 so successful. The VT series comprises four compressors with capacities from 115 to 315 cfm. These new machines have taken power/weight ratios into a new dimension, being lighter and more compact than any other type of compressor, piston or rotary, in their class.

- All machines are TURBO-COOLED – 100% air-cooling – no risk of freezing or overheating and they work with equal efficiency anywhere in the world.
- The VT machines are the result of major changes in design and production methods. They are the only compressors with the crank-case, bellhousing and cylinder ducting in one piece welded design.
- Basic simplicity eliminates maintenance problems—local mechanics anywhere can service these units; the canopy is completely stripped in minutes; loosen three bolts and the complete engine-compressor unit lifts out; un-screw one nut and all four valves in the low pressure cylinder can be removed.
- The FUELMISER automatic speed adjuster means smooth running and fuel saving of up to 25%.
- Manhandling on site is a simple operation due to the low weight and pivoting nose wheel. Torsion bar suspension and built-in lifting eye simplify transport problems.
- Powered by rugged Deutz 4-stroke air-cooled diesel engines, backed by a world-wide service organisation.
- Both compressors and engines use the same type of lubricant.
- Fully automatic drain cocks simplify daily operation.



Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local Atlas Copco company or agent or write to: Atlas Copco AB, Stockholm 1, Sweden

P37

Bersimis river dam under construction near Forestville, Quebec

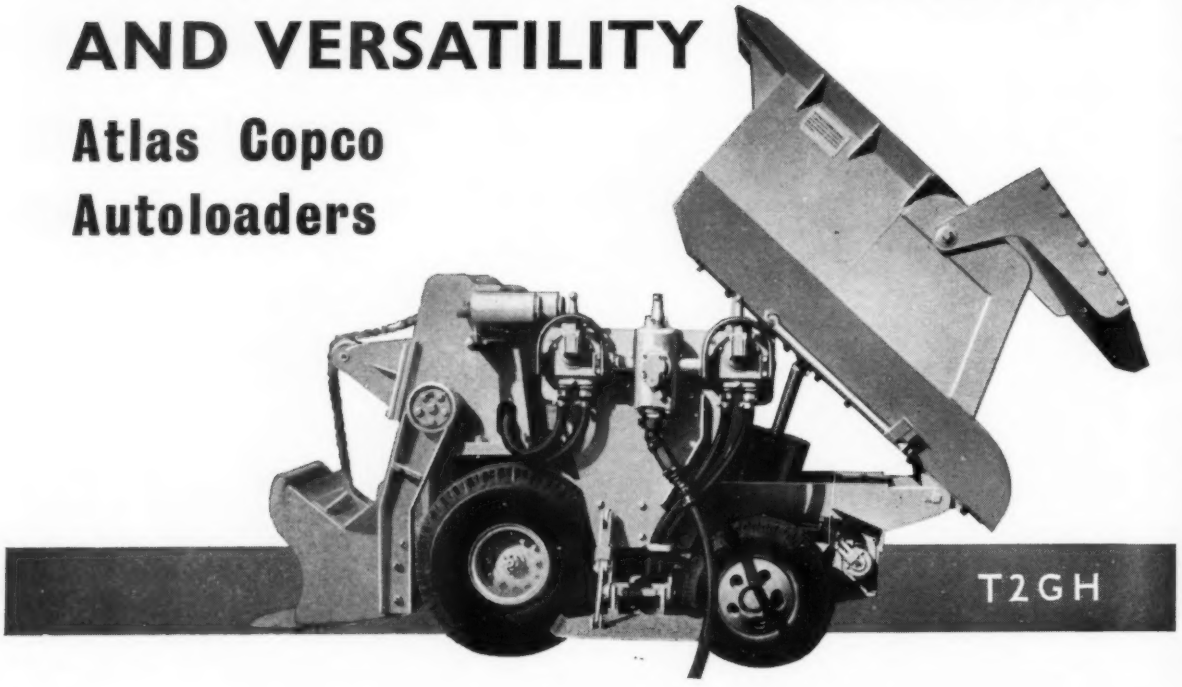
Cantilever Shuttering

In Canada, on the Bersimis river, Blaw-Knox shuttering consisting of 7½ ft. high cantilever-type steel forms are being used, this being a departure from the conventional 5 ft. high form commonly used in North America. The larger forms were designed and fabricated by the Blaw-Knox Company's Equipment Division, Pittsburgh, and are expected to enable the work to be finished with about 30% less movement of forms and a corresponding saving in construction time. The dam will require about a million cu. yards

Blaw-Knox cantilever shuttering in use on the Bersimis dam

UNRIVALLED FOR EFFICIENCY AND VERSATILITY

Atlas Copco Autoloaders



Operated by one man. The complete work cycle — mucking, transport and dumping can be carried out by one man. This reduces labour costs considerably.

Independent of track. Owing to the fact that the autoloader is not rail bound it has an unlimited loading width. Mucking can be carried out just as easily in narrow drifts as in large underground excavations. In addition costs for track laying are eliminated.

Low maintenance costs. Rubber tyres reduce stresses on the machine resulting in lower maintenance costs. The tyre costs per ton loaded vary with working conditions but generally these are extremely low.

Another advantage of pneumatic tyres is that the loader can run over the air hose without the least risk of hose breakages.

High capacity. The capacity is dependent on the distance between the loading and dumping sites, but for instance, with a haulage distance of 70 ft., capacities of up to 55 cu. yds. of material per hour have been obtained.

Many ranges of application. Being independent of tracks the machine can operate over larger areas than track-bound loaders. It can be dismantled quickly and easily if shaft dimensions make transport difficult.

This machine is available in two versions, T2G and T2GH. T2GH has a higher discharge height and is designed especially for dumping on conveyor belts.

Atlas Copco autoloaders are used throughout the world in various ranges of application such as cut-and-fill-stoping in ore mines, seam drifts in coal mines and for loading operations at the surface.

A complete range of compressed air equipment

Atlas Copco manufactures portable and stationary compressors, rock-drilling equipment, loaders, pneumatic tools and paint-spraying equipment. Sold and serviced by companies or agents in ninety countries throughout the world.

Atlas Copco PUTS COMPRESSED AIR TO WORK FOR THE WORLD

Contact your local company or agent or write to Atlas Copco AB, Stockholm 1, Sweden, or Atlas Copco (Great Britain) Limited, Beresford Avenue, Wembley, Middlesex.

L.33

of concrete. The concrete is placed at the rate of about 165 cu. yards per hour, working 20 hours per day, and the schedule provides for a shutdown on the concreting work nine months during the winter, half of which will occur during the winter of 1958–1959.

Concrete is hauled from a nearby batching plant which is fitted with two 9,000 ton silos and four 2 cu. yard batchers. The batches are delivered to a 25 ton cableway by an electrically operated transfer car and 8 cu. yard buckets are employed to lift the concrete to the body of the dam.

The central spillway, 310 ft. long, will include six 40 ft. clear openings. Water from the resulting lake will travel through a 2,700 ft. long tunnel to a power house containing five 171,000 h.p. turbines.

Much of the construction work has taken place under highly adverse weather conditions, temperatures ranging from zero to 50° below. It was these low temperatures that provided the major objection to the use of steel forms but the required insulating effect was provided by the use of a spray compound. This consisted of a combination of asphalt and asbestos and was applied to forms in a ¾ in. thick layer designed to last throughout the construction period of the project. The Blaw-Knox forms, with or without insulating compound, are prefabricated.

A design feature enables the forms to support and locate plastic water stops through the transverse construction joints in the dam. The use of these relatively high forms is expected to increase where large bulks of concrete are being placed because of the ease with which they can be applied in field operations and because of the reduced amount of rehandling required to complete any given project.

Abstracts from the World Technical Press

Electrification Progress in French Africa

The author gives a short survey of the hydraulic resources in Africa, stress being laid on territories controlled by, or associated with, France. The French effort is illustrated by the figures given for the territories during the period 1946 to 1952, which show an increase from 23,250 to 74,100 kW in installed capacity, and from 44·6 to 150·1 million kWh in yearly output. Developments have spread to a particularly wide extent in French West Africa and Madagascar, where, during the seven-year period, production increased from 18·6 to 60 million kWh, and from 19·3 to 52 million kWh respectively. (*Indian Journal of Power and River Valley Development*, Vol. VIII, No. 7, July 1958, p. 22, 3 pp., 4 ff.)

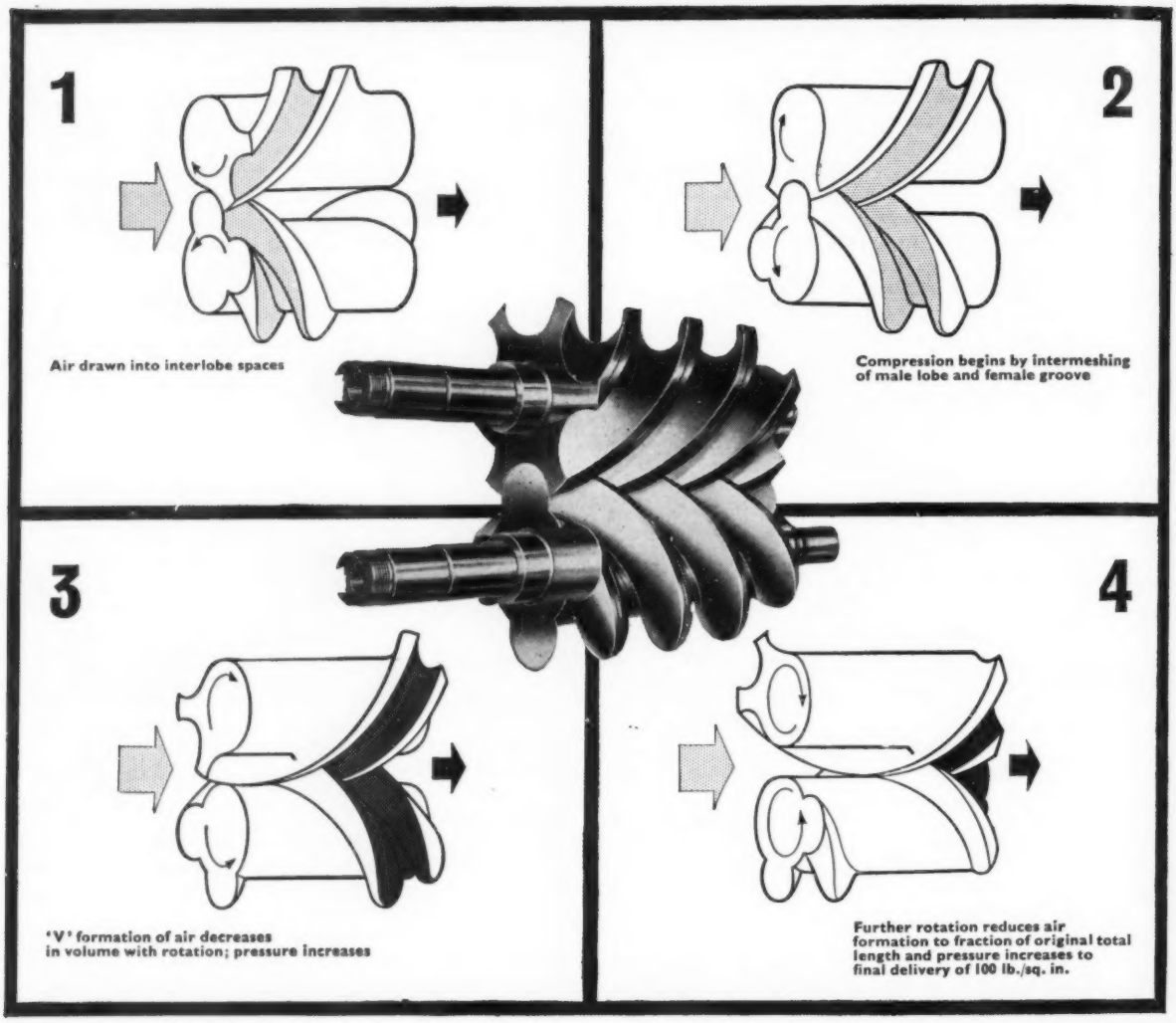
The Ackersand—II Plant

The power house of this new Valais plant, the first of the two 36,000 kVA generating sets of which was put into operation on October 25, 1958, stands at a right angle with the old Ackersand—I plant, completed in 1908. The two power houses are connected by a building which houses the control room and the workshops. These two plants, to which a third will be added farther upstream at a later date, harness the waters of the Vispe river, which, from the confluence of its two branches, the Matter Vispe and Saaser Vispe, flows due north to join the Rhône near Visp. The 12 km. stretch between the intake and Mattsand and the tailrace at Ackersand has a head of 529·5 m. gross and 485·5 m. net. The intake leads through a two-chamber sand trap to a 210,000 cu. m. balancing reservoir which made it necessary to divert a 500 m. stretch of the river into a new bed lying between the east bank of the reservoir and the Visp-Zermatt railway. The supply system consists of a short surface conduit of reinforced concrete 367 m. long, a 12,218 m. pressure tunnel, a surge tank, a 900 m. inclined pressure shaft, and a short horizontal penstock laid at its upstream end under and across the railway line, its downstream section being carried by a steel bridge across the river. The tailrace is only about 70 m. long. Tunnelling was difficult owing to faults and deficient geological conditions, and it was necessary to erect a strong reinforcement of steel arches over the greater part of the tunnel. In the tunnel and inclined shaft a reliable support was achieved almost without timbering, so that concreting could proceed undisturbed. The rate of concreting was considerably accelerated by the use of collapsible steel shuttering which enabled the whole profile to be concreted in one operation; daily concreting output varied between 37 and 45 m. In the carbonaceous section leading to the surge tank and in similar sections of the inclined shaft, workers were provided with safety pit-lamps, owing to the presence of gas; in addition, the very dry surface of the rock was kept artificially wet during work. The erection of the shell of the power house was completed according to schedule within a year and consists of prefabricated ferro-concrete trusses, girders and roof slabs. The two 50 ton travelling cranes were put in operation for the erection work, their track girders having been fitted as soon as work on the power-house building had sufficiently progressed. In spite of all the difficulties encountered and the hazards they entailed, the whole plant was completed without any serious accident to personnel. (Dipl. Ing. E. Etambach, *Schweizerische Bauzeirung*, Vol. 77, No. 5, January 29, 1959, p. 59, 7 pp., 16 ff.)

Sediment Transportation

The study of this problem has given rise to an abundance of experimental research. This paper approaches it, however, from a purely theoretical angle, and attempts to arrive at a right comprehension of the problem. The author begins by emphasising the influence of the flow on sedimentation, that is, the reaction of the flow on particles of bed material. He then considers the condition of equilibrium of the forces acting on the bed load, and taking into account the result of experimental research, he draws up an equation expressing the initial drifting of the particles. In the following sections, a system of equations expressing the characteristics of a particle in motion is established. On the one hand, these equations define, in functions

Portable air compression the Holman way


1
Air drawn into interlobe spaces
2
Compression begins by intermeshing of male lobe and female groove
3
'V' formation of air decreases in volume with rotation; pressure increases
4
Further rotation reduces air formation to fraction of original total length and pressure increases to final delivery of 100 lb./sq. in.

Rotair *simple—and so much more efficient*

The Holman Rotair portable rotary screw compressor gives pulseless outputs up to 600 cubic feet a minute *in one stage* with a temperature rise of only 100°F above ambient.

PULSELESS OUTPUT
NEGLIGIBLE COMPRESSOR MAINTENANCE
MINIMUM FRICTION
LIGHT WEIGHT
ONLY TWO MOVING PARTS AND FOUR BEARINGS
ROLLS-ROYCE ENGINE (other prime movers to order)

Holman
PNEUMATIC EQUIPMENT
pays . . . with its life

HOLMAN BROS. LIMITED, CAMBORNE, ENGLAND
A company in the Holman Group which has branches, technical representatives and agents throughout the United Kingdom and the world.
Telephone: Camborne 2275 (10 lines)
Telegrams: Airdrill Telex, Camborne
London Office: 44 Brook Street, W.1
Telephone: HYDe Park 9444

THE HOLMAN GROUP

of their variables, the kinetic structure of the motion of the particles and, on the other, the mean velocity of a particle in motion. Proceeding from the results already achieved, the final section of the paper endeavours to determine theoretically the formula expressing solid discharge in a two-dimensional flow. Save in the numerical value of the coefficients, the formula arrived at tallies with Meyer-Peter's formula. (Dr. Ing. Selim Yalin, *La Houille Blanche*, Vol. XIII, No. 6, November 1958, p. 607, 12 pp.,10 graphs.)

Assessing the Quality of Concrete

A reprint is given of the paper read at the conference held in Locarno in March 1958 under the auspices of the Swiss Association of Engineers and Architects, the Swiss Materials Testing Association, and the Swiss Committee on Large Dams. When testing concretes intended for use in modern structures in which grave problems of safety are involved, two questions arise: (*a*) are the properties of a given concrete, as ascertained by the careful testing of samples of restricted size, encountered without alteration in the structure itself? (*b*) can the stresses to which these small samples are submitted (uniaxial compression, liability to crack through frost on all faces, etc.) bear comparison with those existing in the structure itself, i.e., stresses in two or three directions, liability to crack through frost on one face only? The author simplifies these two questions to the size of test samples and to the mode of application of stresses, and bases his investigation on a synthesis of the observations made at major dam construction sites in Switzerland. Listing at the outset the properties required from dam concrete (workability, mechanical resistances, imperviousness, resistance to frost and aggressive waters), he then discusses the shape and size of the test samples, rejecting right away the cubic samples of the type generally used to investigate compressive strength. Proceeding from the better results obtained from prismatic samples, which exceed the cubes in height as well as from the fact that the resistance coefficient decreases as the size of the sample increases, he was led to perfecting at Grande Dixence a method of systematic testing in which moulded concrete cylinders 30 cm. in diameter and 45 cm. high were exclusively used. As they weigh no more than 80 kg. each, these cylinders can be handled by two men fairly easily. Reference is made to the lack of homogeneousness of concrete placed in large quantities and to its anisotropy. Resistance of concrete in place is dealt with on the basis of the results obtained at Grande Dixence, Moiry and Malvaglia on samples drawn from the mass by vertical core-drilling, the cores being cut up in cylinders 30 cm. in diameter and 45 cm. high, similar to the moulded cylinders, but kept in a warm and damp room. As to the resistance of concrete to triaxial stresses, the difficulty and complexity of the problem is emphasised, and the author explains the method he applied at Mauvoisin and Moiry, where for each spot under investigation the compressive stress is "penalised" by increasing it to 1·4 times the tensile strength. Finally, the qualities of resistance required of the concrete from the construction site are discussed. With regard to the safety coefficient, the author states that at most construction sites in Switzerland, the method developed by A. Stucky at Mauvoisin has been adopted, that is to say, the safety coefficient is made to depend upon a scattering of the control tests. It seems indeed logical that the coefficient of safety should take into account not only the mean resistance of concrete, but also the risk of obtaining now and again a very bad result. This risk increases with the scattering of individual resistances. The paper outlines the present trends in the technology of concreting, i.e., systematic control at construction sites by drawing samples in accordance with the scale of the structure under investigation, mechanised and automatic manufacturing of concrete, improved interlocking devices, intensifying research into the workability of concrete, systematic placing and mechanised vibrating. These various conditions are likely to generalise in a near future the use of lean mixes which have the advantages of being more economical and of restraining the heat of hydration. (J. P. Stucky, Consulting Engineer, Lausanne, *Bulletin Technique de la Suisse Romande*, Vol. 84, No. 15, July 19, 1958, p. 255, 8 pp., 15 ff.)

NOTE. Two more papers read at the Locarno Conference appeared in BTSR, one on "Portland and Special Cements," by H. Lafuma, in the same issue, pp. 249 to 255, and the other on "Technique of Concrete Manufacture and Transport at Medium and Small-size Construction Sites," by J.-Et. Cuenod, Geneva, in No. 16, August 2, 1958, pp. 265 to 276.

The New Cancano Dam

This structure closes the Val Fraele, not very far from the Engadin border, through which flows the Adda river. The main characteristic of this stream is that the Lake of Como actually forms its middle stretch, the Adda joining the lake on its eastern shore, not very far from its north tip, and leaves it near Lecco, to pour into the Po east of Piacenza. The outstanding feature of the new dam—the old dam of the same name has been breached and submerged—is that when it reaches its ultimate height of 172 m. it will be one of the highest arch-gravity structures in Europe. The reservoir it creates will act as the main storage for the Premendia power station of the Milan Corporation. The first construction stage of the dam, now concluded, ensures a storage of 123 million cu. m., which will rise to 240 million cu. m. once the crest has been raised to 172 m. With the 64 million cu. m. available at the existing S. Giacomo dam farther upstream, the aggregate storage available will be 304 million cu. m. The dam, 390 m. in length and 343·4 m. in span at the crest, has a thickness of 25·9 m. at the base and 5 m. at the crest (first stage). It consists of 27 blocks averaging 14 m. in width, which are separated by radial sub-vertical joints. The concrete body of the dam has its upstream face fully covered by granite slabs, but the downstream face has been left bare. Steel wall-clamps with sleeve joints have been let into it in anticipation of the requirements of the ultimate construction stage. The article deals exclusively with the construction problems encountered; there were many and had to be tackled under difficult conditions. Construction work itself is described at length. By 1953, excavation work for the foundation of the dam had been completed, and the up-to-date construction and concreting plant, as well as all the ancillary installations and dwelling accommoda-

tion for the workers, were ready. Concreting proceeded at the following rate: 115,000 cu. m. in 145 days in 1954; 180,000 cu. m. in 190 days in 1955; 130,000 cu. m. in 160 days in 1956, when the dam reached the height of its first stage, 1,902 m. above sea level. Separate paragraphs are devoted to the criteria adopted for the selection of cement, the construction plant, excavation work for the foundations, concrete pouring, concrete testing at the laboratory attached to the construction site, grouting, and the use of additives. The extent of grouting is best illustrated by the figures given for the aggregate length of injection holes drilled and the total weight of cement injected: 56,200 m. and 640 metric tons. The laboratory was equipped with a full range of testing apparatus, and control testing of aggregates and concretes was effected with the utmost care and thoroughness, not only before and during mixing, but also on concrete twelve months in place. The sample cores drawn from various sections of the dam showed the following characteristics: mean compressive strength 465 kg. per sq. cm.; mean elastic- dynamic modulus, 440,000 per sq. cm.; permeability proved to be nil after 10 days of testing at 25 atm. The cement content of the mix, fixed at 250 kg. per cu. m. during the first year, was reduced to 244 kg. during the second year, when Fridoplast was added, and 235 kg. during the third year, the 244 kg. mix being reverted to when it was decided to raise the crest of the dam 4 m. (Dr. Ing. Eugenio Barioli, *L'Energia Elettrica*, Vol. XXXXV, No. 12, December 1958, p. 1165, 14 pp., 19ff.)

Sediment Transportation

The size borderline between suspended and bed-load materials is one of the highly controversial questions occurring in the study of transportation in rivers, and of silting up in natural and artificial reservoirs. Prandt, Kurzmann and others have worked out formulae which apply mainly to the distribution of suspended particles and show that very small particles are fairly evenly distributed from top to bottom of the flow while larger particles are found only in the vicinity of the bottom. What the author is aiming at is to find the border size between suspended and bed particles. The 1·0 mm. border size advocated by Ertl, and generally accepted in Bavaria, is rejected. The model tests carried out at the Hydraulics Laboratory of the Federal Technical University in Zurich have established that an even vertical distribution occurs only for particles under 0·1 mm. in size, while larger particles remain in the vicinity of the bed and move on occasions by either rolling or rebounding, so that they cannot be considered as a suspended load. This border size, however, was ascertained in the testing channel of a laboratory and can hardly be applied to natural conditions. Comparative measurements made in the Aare River and in Bavarian rivers have proved that in almost all samples examined, the share of $>0{\cdot}2$ mm. particles is very small, and only samples drawn from the vicinity of the bed contain a large part of coarse sand particles up to 2 mm. A table giving the composition of the samples in five grades varying from 0·5–0·2 mm. for the coarsest grade to $<0{\cdot}02$ mm. for the finest, confirms that the coarser particles show the lowest percentage. Disregarding therefore the very small share of coarse particles, the author advocates for Bavarian rivers the border size of 0·2 mm., a size which had already been proposed by Seifert for North German rivers. It also applies, according to Professor Müller, of Zurich, to the major rivers in Switzerland. (Dr. Jean Burz, *Die Wasserwirtschaft*, Vol. 48, No. 14, November 1958, p. 387, 3 pp., 4 graphs.)

Improving Kaplan Turbine Efficiency

A description is given of the tests carried out in recent years at major Austrian power stations on behalf of the Austrian Association of Electricity Supply Undertakings for the purpose of establishing the most favourable position of runner and guide vanes in Kaplan turbines. The tests were effected by a method evolved by the author in which only a relative value of the degree of efficiency is required to work out the optimum setting of the runner and guide vanes. The more accurately this value is calculated, the easier the plotting of the runner curves, the points of contact of which with the Kaplan curve can also be determined more exactly. This relative value ψ is derived from the formula $\psi = \frac{\xi}{H\sqrt{\Delta h}}$ in which ξ is the relative value corresponding to the output of the generator, H the head, and Δh the difference of pressure between two appropriate measuring points drilled in the spiral chamber. Leaving aside H, which can always be determined without any difficulty, the reliability of the test results depends on the accuracy achieved in ascertaining the value of the two other factors, above all of Δh, the importance of which is particularly emphasised. The measuring programme, the measuring methods and the evaluation of the results are described. The tests for each turbine of a plant must be effected once for any head, and if all the turbines of a plant are identical, investigation of the head factor need not be repeated. It is claimed that the adjustment of the position of the runner and guide vanes determined by the method produces an average improvement in efficiency of 1·5 to 2%; much higher figures have been reached in small plants. (Dipl. Ing. Dr. Techn. Helmut Böhm-Raffay, *Oesterreichisch Zeitschrift für elektrische Wirtschaft*, Vol. 12, No. 1, January 1959, pp. 1–3.

CLASSIFIED ADVERTISEMENTS

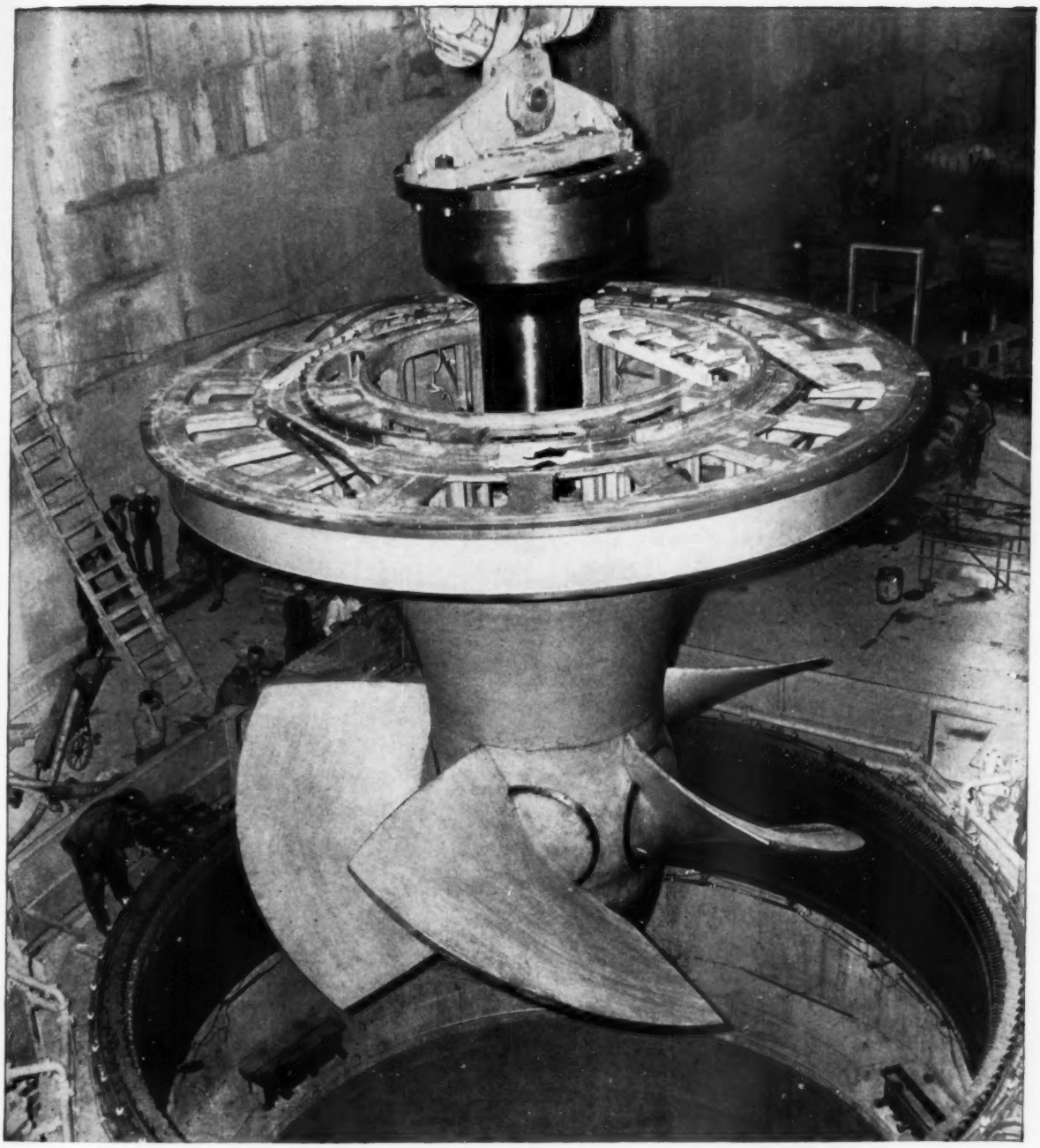
Announcements for this column can be accepted up to the 8th of the month for the following month's issue. The charges are fourpence per word with a minimum of 10s. Box No. facilities 2s. 6d. extra. In order to avoid accountancy it would be appreciated if instructions to insert were accompanied with remittance.

Displayed classified advertising for situations vacant, situations wanted, public appointments, are accepted at £2 10s. 0d. per column inch.

SHOTBLASTING *in situ* by the "on-site" experts. Organic and Inorganic Coatings applied. Anything, anywhere at competitive rates. Darnall Shotblasting Co. Ltd., Doctor Lane, Sheffield, 9. Telephone 42896.

EDITORIAL ASSISTANT

Young Engineer, preferably civil, with an aptitude for technical writing, required shortly as editorial assistant to this journal. Some knowledge of languages an advantage. Ultimate prospect of editorship for the right candidate.—Applications should be addressed to The Editor, WATER POWER, 33 Tothill Street, Westminster, London, S.W.1.

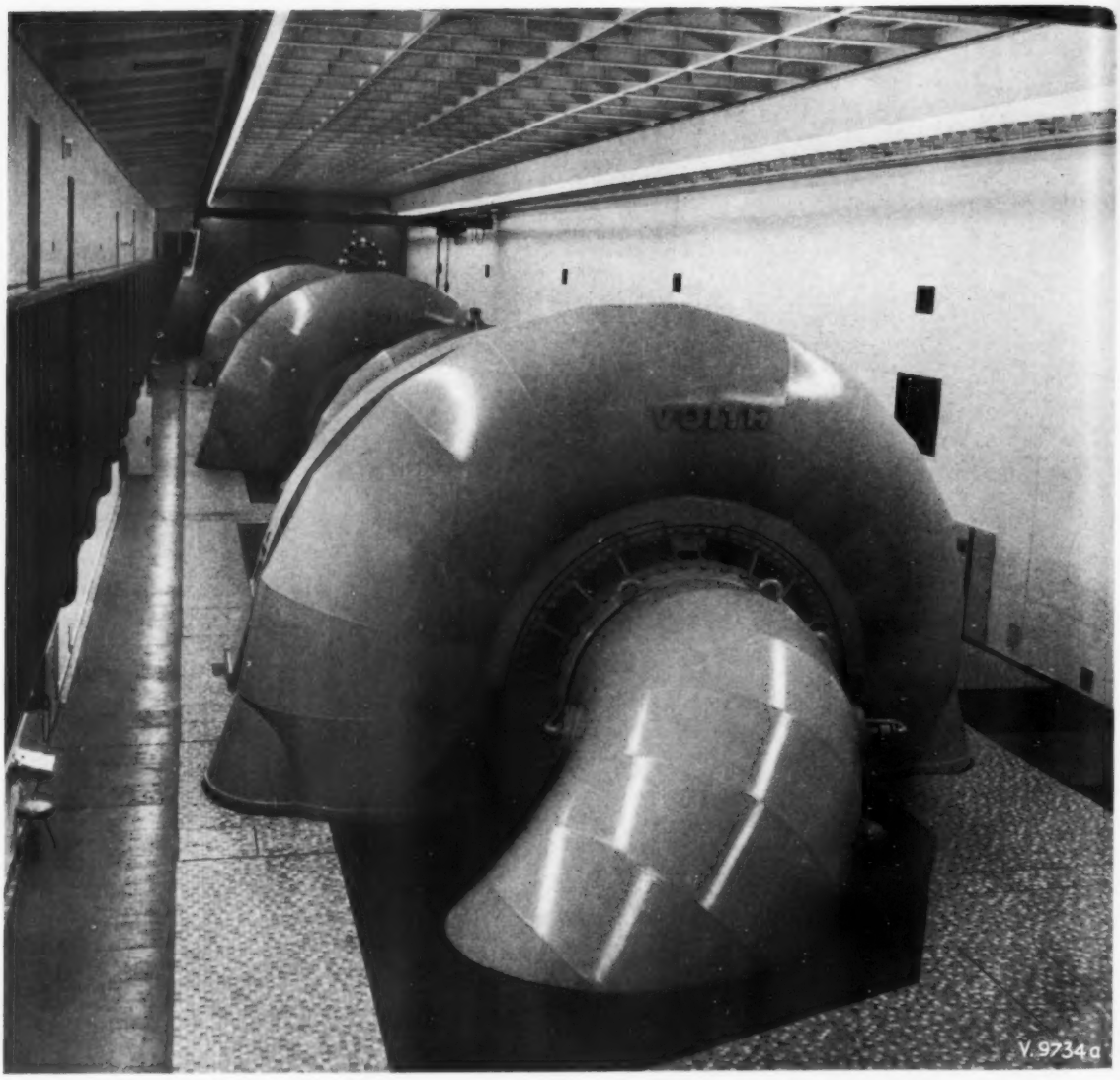


DOMINION KAPLAN TURBINES FOR BEECHWOOD

One of the 45,000 H.P. hydraulic turbine runners being lowered into position at the New Brunswick Electric Power Commission Beechwood power station on the St. John River.

DOMINION ENGINEERING
COMPANY LIMITED, Montreal, Canada

HYDRO-MECHANICAL **VOITH** EQUIPMENT FOR PUMPED-STORAGE PLANTS



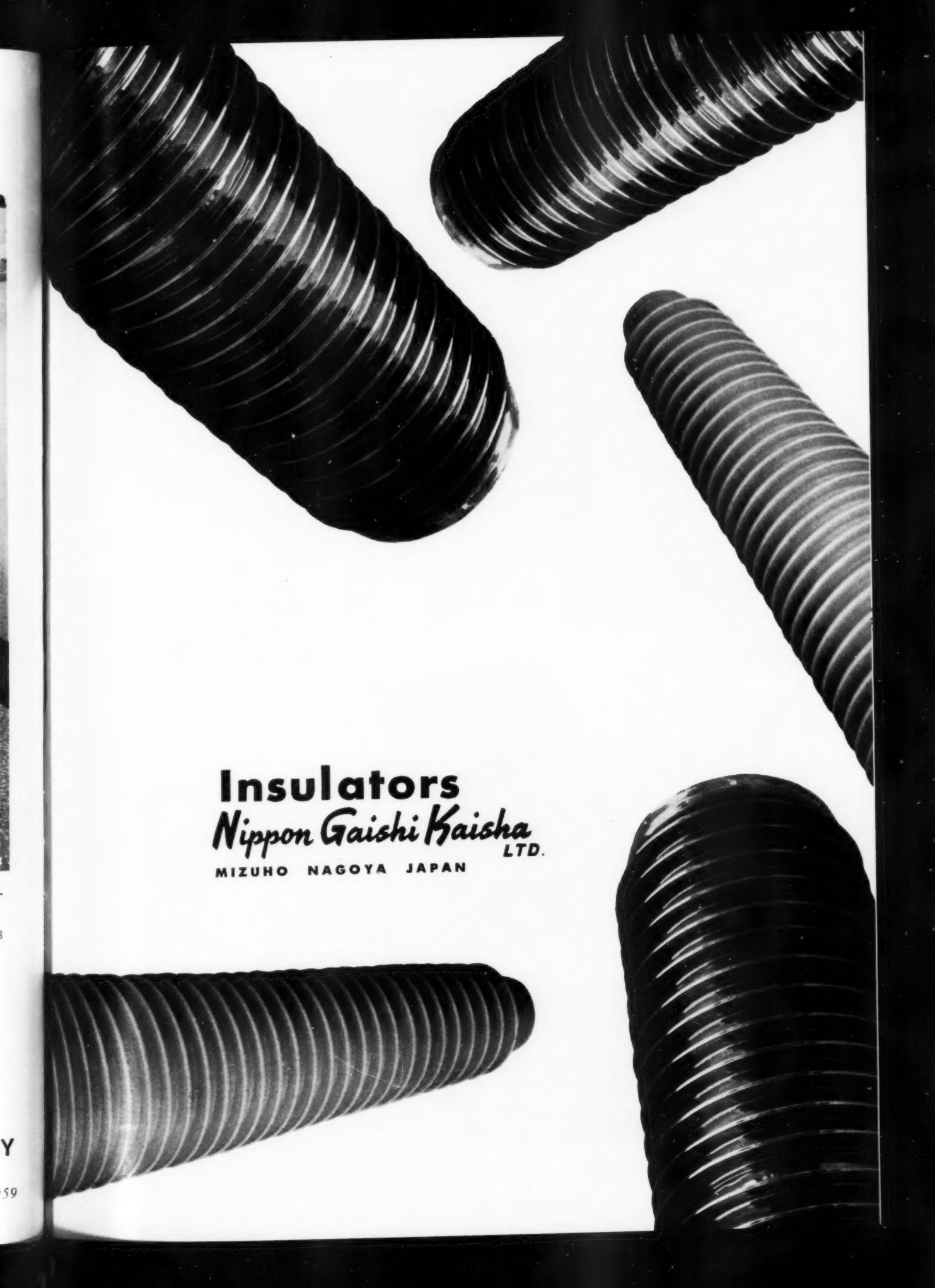
3 VOITH FRANCIS SPIRAL TURBINES, each rated at 58,300 HP at 260 ft. head. installed in the GEESTHACHT PUMPED-STORAGE PLANT of the Hamburgische Electricitätswerke AG.

Voith have also designed, built and delivered for this project 3 weight-actuated butterfly valves for the intakes and 3 hydraulically operated butterfly valves ahead of the turbines, inside diameter of valves 12 ft. 6 in.

Our manufacturing programme for pumped-storage plants includes:—

Turbines of the Kaplan, Francis or Impulse type.
Storage pumps with clutches.
Starting turbines or starting converters.
Speed governors, automatic control equipment.
Shut-off valves for intakes and turbines.
Y-pipes, racks and rack cleaning equipment.

J. M. VOITH GMBH · HEIDENHEIM (BRENZ) · GERMANY

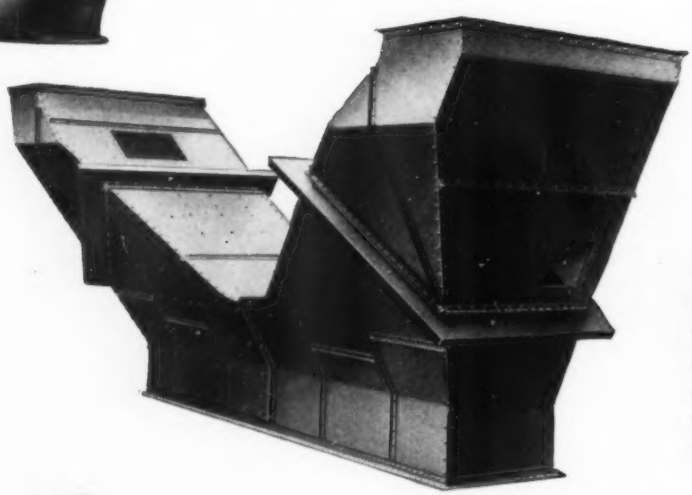

Insulators
Nippon Gaishi Kaisha LTD.
MIZUHO NAGOYA JAPAN

Fabricated Platework

PIPEWORK

We can supply low pressure Steam, Gas and Water Mains and high pressure welded unlined Water Piping. We also specialise in bends of large diameter pipes and branch pipes of complicated design.

to your specification



DUCTS

Ducts of rectangular design for power stations or boiler houses, of electrically-welded construction in Mild or Special Steels or Aluminium Alloy, can also be supplied. They are accurately fabricated to suit your exact requirements.

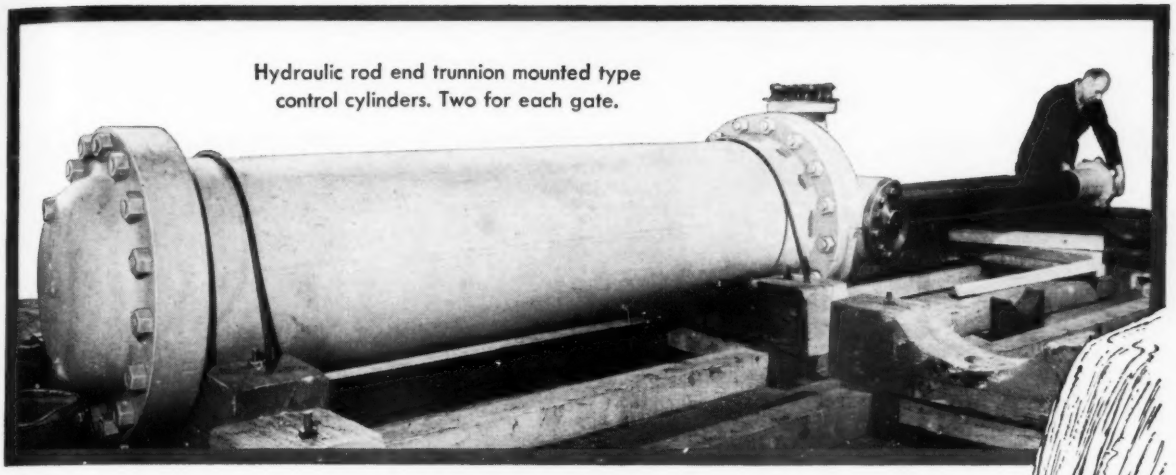
● ***Our Fabrication Service is fully described in our Brochure "FABRICATED PLATEWORK". Write for your copy NOW!***

ALLENS of TIPTON

W. G. ALLEN & SONS (TIPTON) LTD

P.O. Box 4 · Tipton · Staffs

Tel: TIPTON 1266



Hydraulic rod end trunnion mounted type control cylinders. Two for each gate.

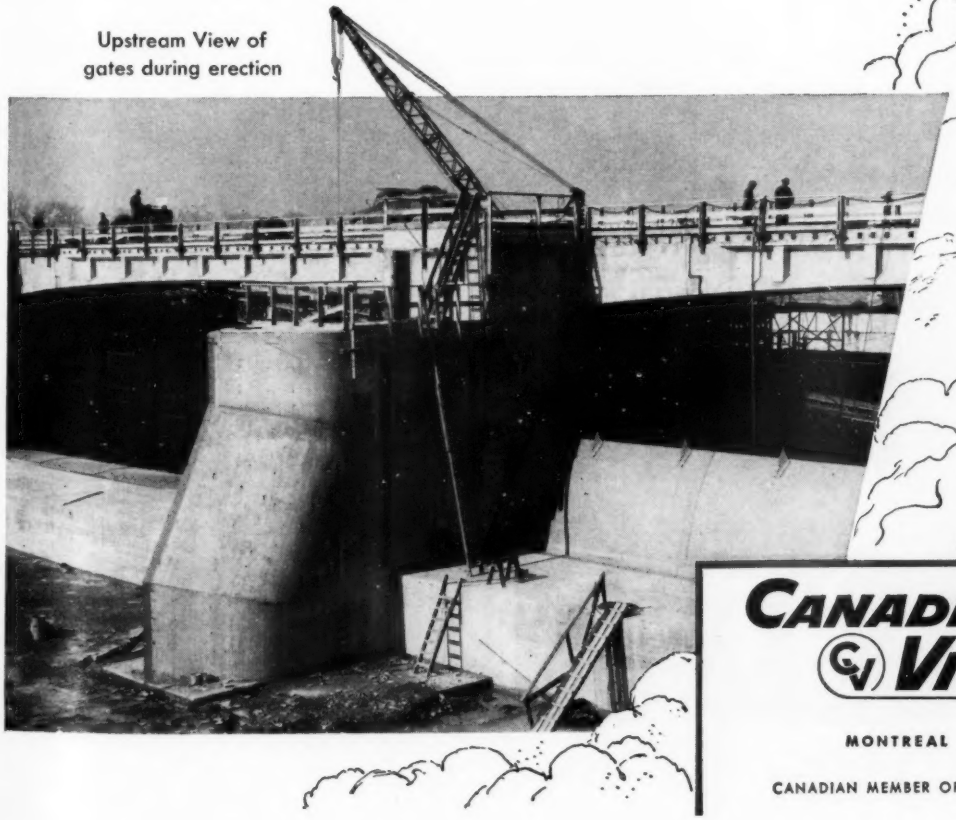
CONTROLLING THE FLOW OF NIAGARA

The flow of Niagara, one of Canada's greatest sources of electric power, is controlled by Vickers-built submersible gates of the "fishbelly" type.

Working with the M.A.N. Company, a Canadian Vickers associate, who designed the 100 ft. wide section welded gates, thirteen gates were supplied along with twenty-six servomotors and thirteen pumping sets which were entirely engineered by Canadian Vickers.

These gates are another example of the precise engineering that goes into all Vickers-built water control equipment.

Upstream View of gates during erection



CANADIAN VICKERS LIMITED

MONTREAL • TORONTO

CANADIAN MEMBER OF THE VICKERS GROUP

le marinel

BELGIUM CONGO

FOUR 89 500 HP VERTICAL-SHAFT FRANCIS TURBINES

operating at 333 r.p.m. under a 179 m. head

hydraulic turbines

equipment of large dams and hydro-electric power plants

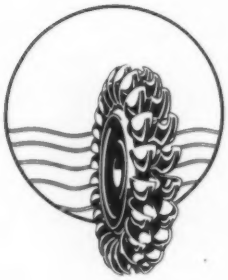
equipment of irrigation networks

drilling turbines

hydraulic couplings

hydraulic Measuring instruments

experimental and theoretical research and studies



GRENOBLE
Avenue de Beauvert
TÉLÉPHONE 44 - 55 - 30

NEYRPIC

PARIS XVI[e]
S, Rue Bellini
TÉLÉPHONE : PÁS 51 - 09

ALLIS-CHALMERS ACQUIRES S. MORGAN SMITH ...FORMS NEW HYDRAULIC DIVISION

On February 1, the S. Morgan Smith Company became a part of Allis-Chalmers. Extensive A-C facilities in Milwaukee, together with two S. Morgan Smith plants in York, Pennsylvania, are now operating as the newly created Allis-Chalmers Hydraulic Division.

In acquiring S. Morgan Smith, A-C combines its own broad background in hydraulics with the 80 years of diversified engineering and manufacturing knowledge of SMS.

The York facilities will be devoted to the continued research, design, engineering and fabrication of a complete line of hydraulic turbines and accessories, pumps and pump-turbines, valves for industrial, waterworks and power applications, and specialized heavy equipment.

Product information or engineering help can be obtained from your nearby Allis-Chalmers office, or by writing Allis-Chalmers, Hydraulic Division, York, Pennsylvania.

HYDRAULIC DIVISION

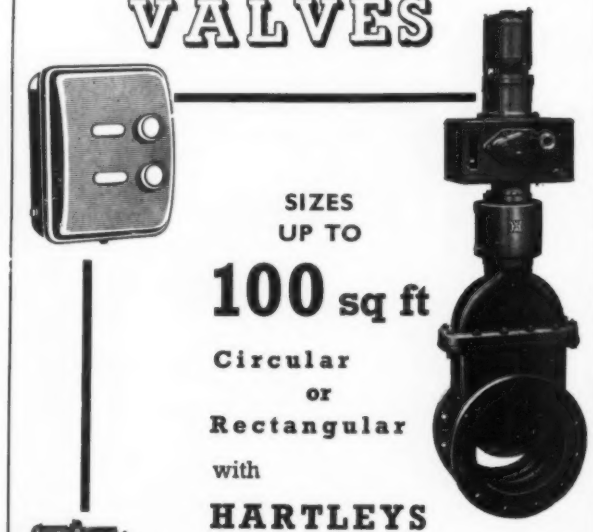
RESEARCH | DESIGN
HYDRODYNAMICS
ENGINEERING | FABRICATION

Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

ELECTRICAL CONTROL OF PENSTOCKS AND VALVES



SIZES UP TO

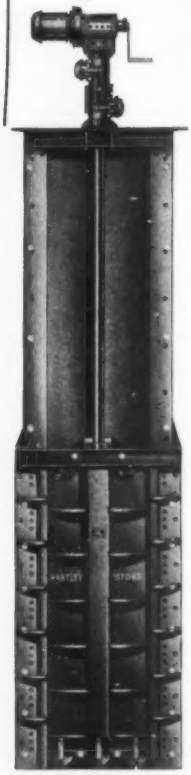
100 sq ft

Circular or Rectangular with

HARTLEYS

"VALECTRIC"

HEADSTOCKS



USED BY LEADING AUTHORITIES including

C.E.A. & L.C.C.

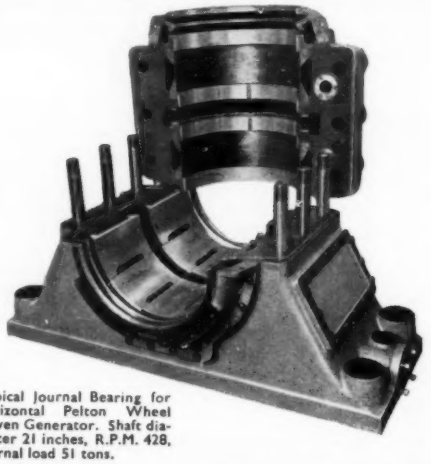
LOCAL or REMOTE CONTROL

TRADE MARK

HARTLEYS (STOKE ON TRENT) LTD.

Phone: Stoke-on-Trent 48627

206



Typical Journal Bearing for horizontal Pelton Wheel driven Generator. Shaft diameter 21 inches, R.P.M. 428, Journal load 51 tons.

MICHELL BEARINGS

The original pivoted pad film lubricated bearings. They carry loads with complete reliability and efficiency with downright simplicity for all Hydro-Electrical installations, and for Marine, Mining, Paper-Making Machinery and other requirements.

MICHELL BEARINGS LTD.

SOUTH BENWALL NEWCASTLE UPON TYNE 5

Telephone 34279 Telegrams: MICHBEARO, NEWCASTLE

THE RAILWAY GAZETTE
A journal of Railway Management, Engineering, Operation, and Railway News. *Weekly 2s. Annually £5 by post.*

DIESEL RAILWAY TRACTION
A monthly review of world-wide developments in diesel-engine design and diesel railway traction. *Monthly 2s. 6d. Annually 35s. by post.*

SHIPBUILDING AND SHIPPING RECORD
A journal of Shipbuilding, Marine Engineering, Docks Harbours, and Shipping. *Weekly 2s. Annually £5 by post.*

NEW COMMONWEALTH
Describes and illustrates significant developments in production, trade, transportation, and related spheres in all countries of the Commonwealth. *Monthly 2s. 6d. Annually £2 by post.*

COLLIERY ENGINEERING
A practical journal for Colliery Managers and Engineers, and manufacturers of Colliery Equipment. *Monthly 2s. 6d. Annually £2 by post.*

COKE AND GAS
A technical journal dealing with the scientific and technical problems involved in the production of coke and gas in coke ovens and gasworks. *Monthly 2s. 6d. Annually 35s. by post.*

THE INDUSTRIAL CHEMIST
A journal devoted to the progress of applied Chemistry and Engineering. *Monthly 2s. 6d. Annually £2 by post.*

ARCHITECTURE AND BUILDING
A practical journal devoted to Architecture and Building Practice. *Monthly 2s. 6d. Annually 35s. by post.*

WOOD
A practical journal, authoritatively written, superbly illustrated, dealing with the growth, marketing, and use of wood in all its forms. *Monthly 2s. 6d. Annually 35s. by post.*

FOOD
A journal devoted to the manufacture, packaging, and marketing of processed foodstuffs. *Monthly 2s. 6d. Annually £2 by post.*

WATER POWER
A technical journal devoted to the study of all aspects of Hydro-Electric Development. *Monthly 2s. 6d. Annually £2 by post.*

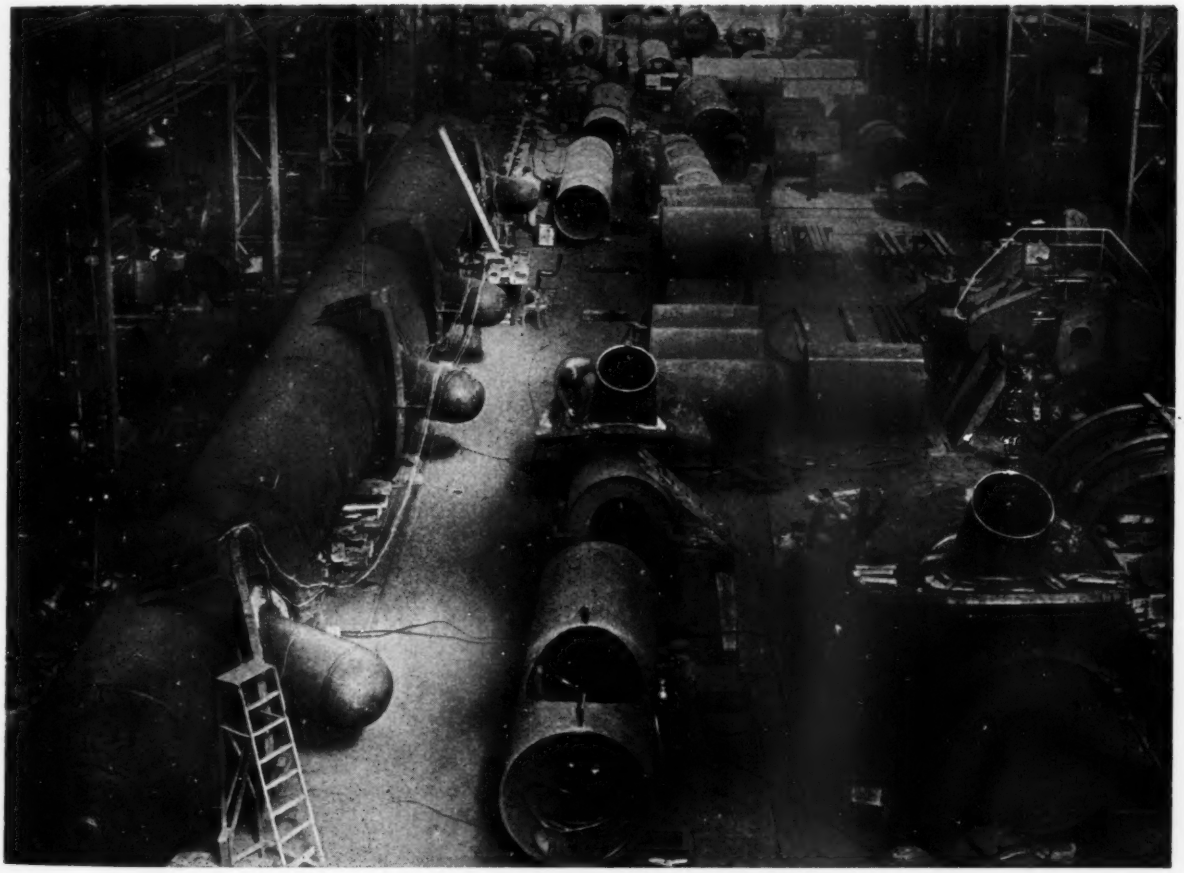
THE RAILWAY MAGAZINE
A popular magazine containing illustrated articles on Railways and Locomotives. *Monthly 2s. 6d. Annually 35s. by post.*

MINE AND QUARRY ENGINEERING
Articles of technical nature cover geology, modern methods of prospecting, the winning of ore and stone, the dressing of ore and minerals, and extraction metallurgy. *Monthly 2s. 6d. Annually 35s. by post.*

TOTHILL PRESS LIMITED

33, Tothill Street, Westminster, London, S.W.1

Penstocks, pressure shafts linings,
Substation steel structures
Gantry and overhead travelling cranes
Pylons, water gates

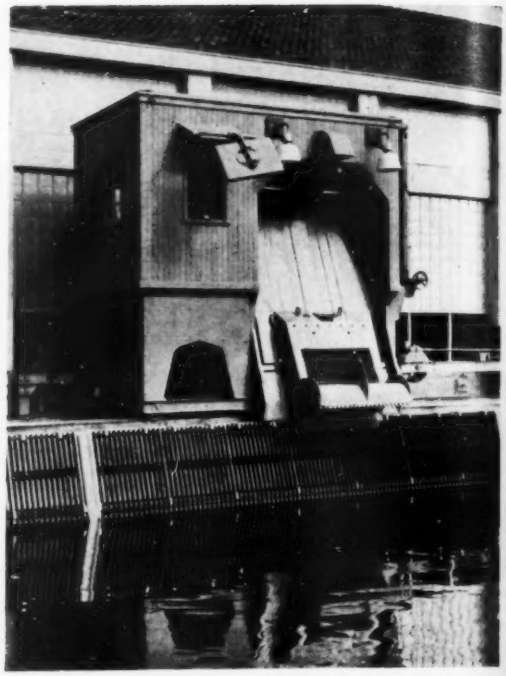


Downstream portion of the Grande Dixence Fionnay Power Station distribution pipe during tensometric shop tests. Max. wall thickness 52 mm., service pressure 96 at., test pressure 121 at.

GIOVANOLA Monthey - Switzerland

HIGH
ENDEAVOUR
Ceretti & Tanfani have been pioneering cableway and ropeway development for nearly 70 years.
The cableway shown here places 350 tons of concrete per hour. The span is over 3,000 feet and the masts are 360 feet high. It is helping to build the Rihand Dam in India.
In Switzerland at Grande Dixence another Ceretti & Tanfani cableway has a capacity of 950 tons per hour.
Ropeways, Cableways, Cranes, Bulk handling plant, Silos—our experience covers all mechanical handling equipment and is at your service.
CERETTI & TANFANI
ROPEWAY CO. LTD.,

CERETTI & TANFANI ROPEWAY CO. LTD.
Imperial House, Dominion St., London, E.C.2
CERETTI & TANFANI S.p.A.
Via Durando 18, Milan, Italy



Racks and

Rack Cleaning Machines

for

HYDRO-ELECTRIC POWER PLANTS

WATER PURIFICATION PLANTS

PUMPING STATIONS

ENGINEERING WORKS

JONNERET S.A.

GENEVA (JUNCTION) SWITZERLAND

CP

CP **SCARPA & MAGNANO**

Head Office & Works: SAVONA (Italy) VIA FIUME 2
Comm. Management: MILAN (Italy) VIA MANZONI 12

METAL-CLAD SWITCHBOARDS, LINE CP FOR INDOOR AND OUTDOOR, WITH SINGLE OR MULTIPLE BUS-BAR SYSTEM

Rated voltages: 10 - 15 - 20 - 30 KV
Bus-bars rated currents: 600 - 1000 - 2000 Amps
Circuit breaker rated currents: 600 - 1200 - 2000 Amps
Symmetrical breaking capacities: 300 - 500 - 600 MVA

INDEX TO ADVERTISEMENTS

A

A.C.E. Machinery Ltd. ... ... —
A.C. Plant & Hire Co. Ltd., The ... ... —
Acciaieria E Tubificio Di Brescia ... ... —
Allen, W. G. & Sons (Tipton) Ltd. 58
Allgemeine Elektricitäts-Gesellschaft 17
Allis-Chalmers Hydraulic Division ... ... 30 & 61
Allmanna Svenska Electriska Aktiebolaget 35
Aluminium Wire & Cable Co. Ltd. ... ... —
Anderson, Grice, The Company, Ltd. ... ... —
Ansaldo San Giorgio, S.p.A. 18
Armfield Hydraulic Engineering Co. Ltd. ... ... —
Associated Electrical Industries Ltd. 39
Ateliers de Constructions Electriques de Della ... —
Atlas Copco, A.B. ... ...51, 52 & 53
Autair Ltd. ... ... —

B

Bell, Theodore & Co. Ltd. ... ... —
Birkett, T. M., Billington & Newton Ltd. ... ... —
Bochumer Verein 67
Bouchayer & Vialett ... ... —
Boving & Co. Ltd. ... ... Front Cover
British Insulated Callender's Cables Ltd. ... ... —
British Pitometer, The Co. Ltd. ... ... —
British Ropeway Engineering Co. Ltd. ... ... —
British Thomson-Houston Co. Ltd. 39
Brown, Boveri & Co. Ltd. 25
Bruce, Peebles & Co. Ltd. 31
Bucyrus-Erie Co. Ltd. ... ... —
Buss, A.G. 40
Butters Bros. & Co. Ltd. 34

C

Canadian General Electric Co. Ltd. ... ... —
Canadian Vickers Ltd. 59
Ceretti & Tanfani Ropeway Co. Ltd. 64
Charmilles Engineering Works Ltd. 20
Cockburns Ltd. 43
Commonwealth of Australia ... ... —
Compagnie Industrielle de Travaux ... ... —
Consolidated Pneumatic Tool Co. Ltd. 44
Crompton Parkinson (Export) Ltd. ... ... —

D

de Roll, Louis, Ironworks Ltd. ... ... —
Dominion Engineering Co. Ltd. 55
Doulton Industrial Porcelains Ltd. ... ... —
Drees & Co., G.m.b.H. ... ... —
Dresser Manufacturing Division ... ... —

E

Eimco (Gt. Britain) Ltd. ... ... —
ELIN, A. G. ... ... —
English Electric Co. Ltd. 3
English Steel Forge and Engineering Corporation Ltd. ... ... —
Escher Wyss Ltd. 23

F

Ferguson Pailin Ltd. ... ... —
Ferranti Ltd. 11
Fischer, Ltd., George 42
Ferrum Montage ... ... —

G

Galileo Officine di Battaglia Terme ... ... —
General Electric Co. Ltd. ... ... —
Gilbert Gilkes & Gordon Ltd. ... ... —
Giovanola Freres, S. A. 63
Glenfield & Kennedy Ltd. 14

H

Harland Engineering Co. Ltd., The ... ... —
Hartley's (Stoke-on-Trent) Ltd. 62
Helicopter Sales Ltd. ... ... —
Helicopter Services Ltd. ... ... —
Henderson, John M. & Co. Ltd. 26
Henley's W. T., Telegraph Works Co. Ltd. 12
Heywood & Co. Ltd. ... ... —
Hitachi Ltd. 27
Holland & Hannen and Cubitts Ltd. 50
Holman Bros. Ltd. 54
Horseley Bridge & Thos. Piggott Ltd. 45
Huhn, G. ... ... —

I

International Engineering Co., Inc. 8
International General Electric Co. 36
Ingersoll-Rand Co., Inc. 47

J

Jonneret, S. A. Ateliers de Construction 64

K

Karlstads Mekaniska Werkstad, Akt. 5
Krupp, F. ... ... —

L

Leffel, James & Company, The 32
Lepper Transformatorenwerk August 37
Le Materiel Electrique, S-W ... ... —
Lodigiani, Impresa Ing. S.p.A. ... ... —

M

Magrini, S.p.A. 21
Mannesmann-Export, G.m.b.H. ... ... —
Marelli, Ercole & Co., S.p.A. ... ... —
Maschinenfabrik Augsburg-Nurnberg, A.G. 13
Maschinenfabrik Edward Ruch ... ... —
Metropolitan-Vickers Electrical Co. Ltd. Outside Back Cover
Micanite & Insulators Co. Ltd., The ... ... —
Michell Bearings Ltd. 62
Mitchell Construction, The Co. 29

N

Neyrpic 60
Newport News Shipbuilding & Dry Dock Co. ... 7
Nippon Gaishi Kaisha 57
Nuttall, E., Son & Co. (London) Ltd. 16
Nydqvist & Holm, A/B ... ... —

O

Oerlikon Engineering Company ... ... —

P

Phoenix-Rheinrohr, A.G. ... ... —
Pirelli-General Cable Works Ltd. 4

R

Ransomes & Rapier Ltd. ... ... —
Reyrolle, A. & Co. Ltd. ... ... Inside Front Cover
Rheinstahl Union Brückenbau-Akt. Ges. ... ... —
Rip Bits Ltd. ... ...—
Riva Costruzioni Meccaniche ... ... —
Ruhrstahl, A.G. ... ... —
Ruston Bucyrus Ltd. 24

S

S. A. Ateliers De Secheron 28
SACE Costruzioni Elettromeccaniche ... ... —
Salvi, A. & Co. 46
Salzgitter Maschinen Aktiengesellschaft ... ... —
Scarpa & Magnano 65
Siemens-Schuckertwerke, A.G. 48
Smith, Fredk. & Co. ... ... —
Smith, S. Morgan Company ... ... —
Soc. p. Az. Cementi Armati Ing. Mantelli 6
Societa Nazionale Delle Officine Di Savigliano ... —
Societa Elettro-Morsetterie Volpato ... ... —
Societe Dauphinoise d'Etudes & de Montages ... —
Societe des Forges et Ateliers Du Creusot ... ... —
Standard Telephones & Cables Ltd. 41
Steatite & Porcelain Products Ltd. 22
Storey, Thos. (Engineers) Ltd. ... ... —
Strommens Vaerksted A/S ... . —
Sulzer Bros. (London) Ltd. ... ... —
Svenska Metallverken, A/B ... ... —

T

Tampella OY 9
Technoexport 15
Tees Side Bridge & Engineering Works Ltd. ... —
Tokyo Shibaura Electric Co. Ltd. ... ... —
Torno, Giuseppe & Co. 33
Tosi, Franco, S.p.A. ... ... —

V

Vevey Engineering Works Ltd. 19
Vereinigte Osterreichische Eisen-und Stahlwerke ... 38
Victor Products Ltd. ... ... —
Voith, J. M., G.m.b.H. 56
Voith, J. M. (St. Pölten) ... ... —

W

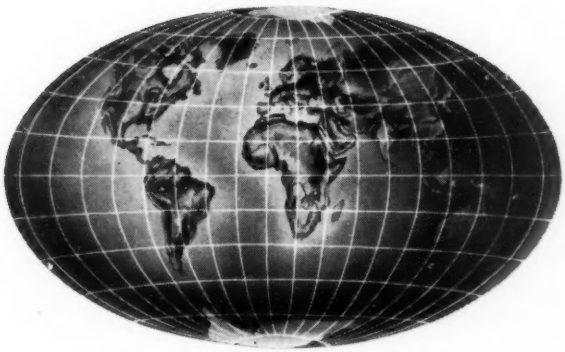
Waagner Biro ... ... —
Wood, Hugh & Co. Ltd. 10

Y

Yorkshire Electric Transformer Co. Ltd. ... ... —

LONDON: Published by TOTHILL PRESS LIMITED, Proprietors of WATER POWER, at 33 Tothill Street, Westminster, S.W.1., and Printed by W. & H. SMITH LTD., Evesham, Worcestershire. *May, 1959*

Water Power Experts
all over the World
rely on Steel Castings and Forgings
made by Bochumer Verein



Our production programme for hydraulic power plants includes:

Forged steel shafts for pumps and turbines.

Runners for impulse and Francis turbines, up to the largest dimensions, in plain carbon or 13 % chromium cast steel.

Kaplan runner blades and runner hubs, spiral casings, stay rings, regulating rings, guide vanes etc.

Spherical valve housings, valve bodies, butterfly valve discs and housings, annular valve housings.

Single and double pump wheels, also in 13 % chromium cast steel, up to the largest dimensions.

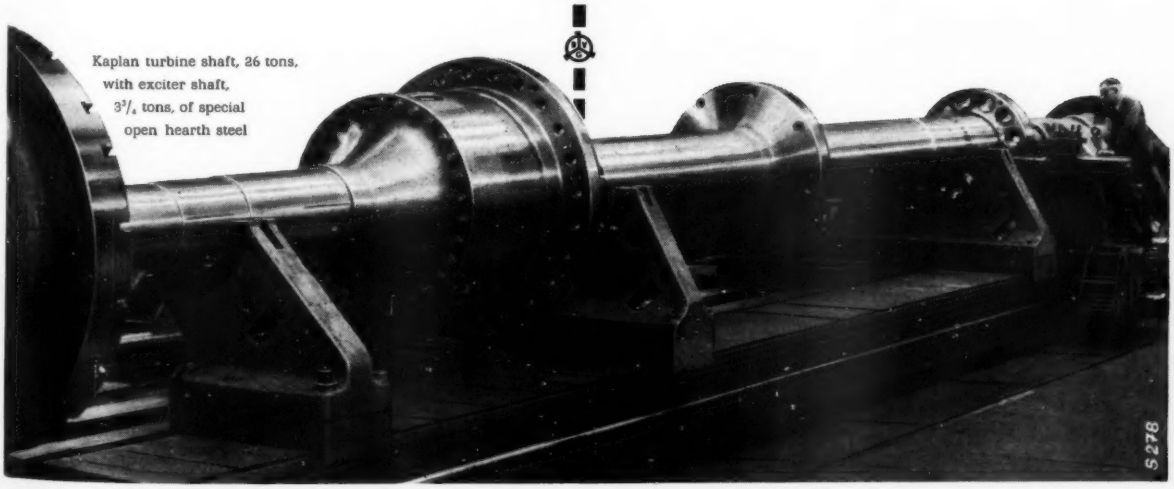
Guide wheels, suction bends, etc.

Most highly stressed forgings and castings are made of our BV-Vacuum Steel.

B V G

Bochumer Verein
für Gußstahlfabrikation AG. BOCHUM

Postbox 325, Bochum (Germany) · Teleprinter: Gusstahl 0825831
Telegrams: Gusstahl



Kaplan turbine shaft, 26 tons, with exciter shaft, 3³/₄ tons, of special open hearth steel

S 278

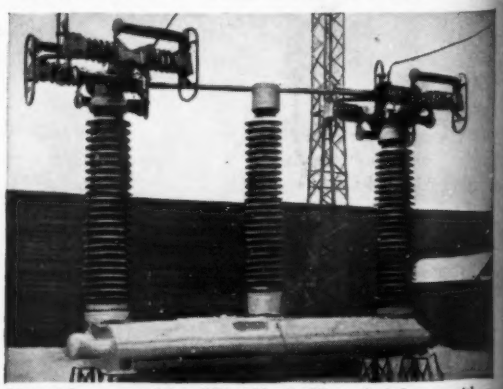
SYDNEY

Switching on more power all over the world

Built to extremely exacting specifications
Metrovick Air-Blast Switchgear gives the highest
standard of performance and reliability under
the most severe conditions in any part of the world.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

An A.E.I. Company



Metrovick are supplying 330 kV Air-Blast Switchgear with a breaking capacity of 10,000 MVA to the Snowy Mountains Hydro-Electric Authority and the Electricity Commission of New South Wales. The photograph shows one phase of a 330 kV breaker prepared for tests, resulting in the granting of ASTA certificate 3946.

METROVICK Air-Blast Switchgear

F/A 900

with a
s Hydro-
w South
breaker
ate 3946.

F/A 903